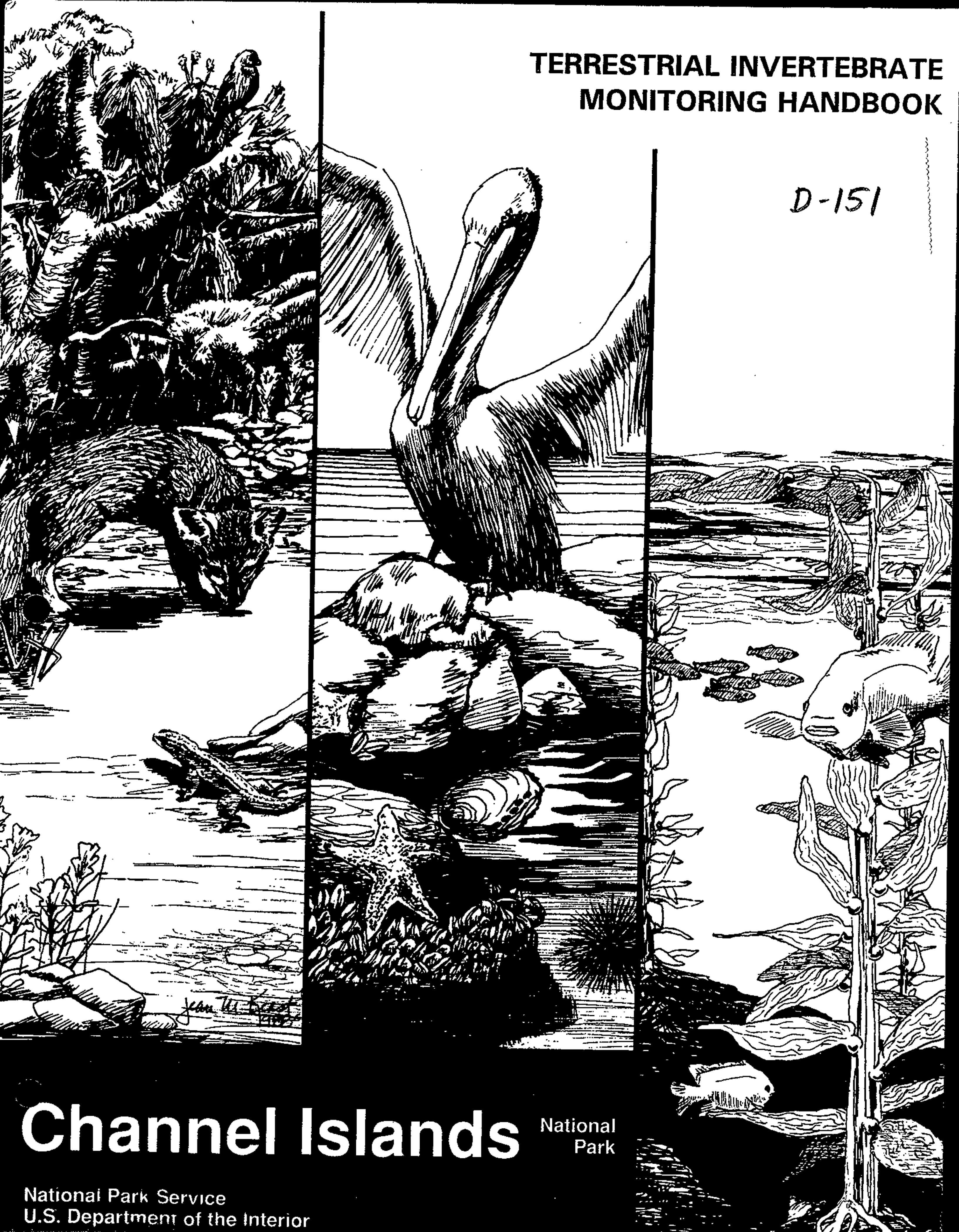
TERRESTRIAL INVERTEBRATE MONITORING HANDBOOK

D-151



Channel Islands National Park

National Park Service
U.S. Department of the Interior

TERRESTRIAL INVERTEBRATE MONITORING HANDBOOK

CHANNEL ISLANDS NATIONAL PARK CALIFORNIA

Gary M. Fellers[1]

and

Charles A. Drost[2]

[1]Point Reyes National Seashore
Point Reyes, California 94956

[2]Department of Environmental Studies
University of California at Davis
Davis, California 95616

National Park Service
Channel Islands National Park
1901 Spinnaker Drive
Ventura, California 93001

November, 1991

TABLE OF CONTENTS

APPENDICES - continued

TABLES

FIGURES

ACKNOWLEDGEMENTS

Channel Islands National Park established the foundation for this study and provided logistical support. The island rangers and boat captains were very helpful in accommodating our transportation and logistical needs while on the islands. Frank Ugolini was especially supportive, not only by making logistical arrangements and relaying communications, but also by taking interest in the study and providing encouragement. We thank Karen Johnston for her time, effort and concern in handling scheduling and communications. Brian Arnold assisted with the collection of some of the San Miguel Island samples. Working on the islands for long periods of time presents special difficulties and hardships. Without the support of those mentioned here, and many others, this study would not have been possible.

The assistance of outside experts was essential to the completion of this project; we especially thank Scott Miller, Julian Donahue and Barry Roth in this regard. The quality of the handbook has been improved by the review and editorial comments of Joan Fellers.

INTRODUCTION

PRESENT STATE OF KNOWLEDGE

Terrestrial invertebrates on the Channel Islands have been studied on an occasional basis since the mid 1800's (Miller and Menke 1981). Miller (1979), however, noted that there was still comparatively little known about the invertebrate fauna and that complete species lists were not available for any island. Since that time, several studies have added considerably to our knowledge of particular orders on the islands: Orthoptera (Rentz and Weissman 1982); Homoptera (Pseudococcidae; Miller 1971, Miller 1973); Coleoptera (Miller and Miller 1985); Lepidoptera (Miller 1984a, Powell 1985); and Hymenoptera (Rust 1985, Rust et al. 1985). Our own surveys, beginning in 1981 on Santa Barbara Island and continuing through 1988 on Anacapa, Santa Barbara and San Miguel Islands, have been aimed partly at helping to fill remaining gaps in the faunal lists for the islands within Channel Islands National Park.

Table 1 (page 16) summarizes the terrestrial invertebrates presently known from Anacapa, Santa Barbara and San Miguel Islands and compares these totals with the lists prepared by the Santa Barbara Museum of Natural History (Hochberg 1979, Miller 1979). A significant number of species has been added to the known fauna of the islands during the past 10 years. Though the lists are still far from complete, most of the groups which remain very poorly known (e.g. the mites and all of the non-arthropod, non-mollusc groups) are also poorly known on the mainland. The present list is, in fact, much superior to anything available for most mainland areas.

In contrast to our increasing knowledge of the composition of the terrestrial invertebrate fauna, there is still an almost complete lack of data on the ecology, distribution and abundance of invertebrates on the park islands. The only major group which has been studied in any detail is the land snails (Hochberg 1979). Recent studies have provided limited ecological data on a few of the insect groups (e.g. Orthoptera, Rentz and Weissman 1982; and Hymenoptera and various others, Miller and Davis 1986, Rust et al. 1985). One of our objectives has been to gather basic ecological data on selected invertebrates as background for the park's monitoring program.

INVERTEBRATE FAUNA

A significant proportion of the terrestrial invertebrates on the Channel Islands is endemic to the islands (Table 2, page 17). The extent of endemism varies depending on the group. For example, the majority of the land snails are endemic, especially on Santa Barbara Island. On the other hand, more vagile groups (e.g. hymenoptera, butterflies) generally have few endemics. Species endemic to the islands are obviously of special interest for the monitoring program. Appendix 1 lists the known endemic taxa from Anacapa, Santa Barbara and San Miguel islands.

Rare and endangered species are also of particular concern to the park and are prime candidates for intensive monitoring. Though none of the terrestrial invertebrates on the park islands are officially listed by the U.S. Fish and Wildlife Service as endangered or threatened, several invertebrates are listed as candidate species (Federal Register 1989) and must be afforded full protection by the National Park Service according to NPS management policies (U.S National Park Service Management Policies, 2 - 78 ed., p. IV - II). Candidate species include the two snails and one beetle listed in Table 3. Since the two snails are found only on park islands, the burden of protecting these species and assuring their well-being falls squarely on the National Park Service.

Many non-native species also occur on the park islands. Almost all of these are widely naturalized on the mainland and may have found their way to the islands on their own. Some non-native invertebrates probably arrived on the islands with shipments of supplies (e.g. Miller 1984b), and a few species have been purposefully introduced as biological control agents (Goeden et al. 1967). Most of these introduced species are most abundant in association with non-native plants and habitats, though some are numerous enough (or are increasing) in native communities that they are of concern. One of the introduced biological control species (cochineal scale, *Dactylopius opuntiae*) has been implicated in the decline of prickly pear cactus (*Opuntia* spp.) on some of the northern Channel Islands.

VALUE OF MONITORING

There is a great diversity of terrestrial invertebrates on the Channel Islands. Invertebrates are an abundant and integral part of every habitat on the islands. A broad-based monitoring program such as the one described here will allow the park to detect significant changes in the diversity, abundance and distribution of invertebrates and hence will provide one of the first indications of change in the island communities. Such change might either be positive (e.g. the recovery of a native plant community and the associated invertebrates) or negative (e.g. immigration or spread of a non-native invertebrate, decline of a native host plant). Changes in the distribution of invertebrates will probably be widespread as changes in the native plant communities continue. Expansion of non-native invertebrates into native plant communities is a serious management concern which will be documented with this monitoring program. Comparisons of the numbers and occurrence of native vs. exotic species will also be made as a further indication of the general "health" of the island communities.

The abundance and distribution of the land snails are of special concern because of their restricted distribution and, in some instances, rarity. Several snail species on the Channel Islands are found nowhere else in the world. Two of these snails are candidates for federal listing as endangered or threatened species; thus, considerable effort should be put into diagnosing and alleviating any problem which arises. These snails are vulnerable to disturbance and their ecology is known well enough that it is appropriate to gather detailed information on trends in population levels. Snails will receive special emphasis to assure the continued survival of this endangered resource.

The invertebrate monitoring program will also document 1) seasonal and yearly fluctuations in population levels and 2) long-term trends in abundance, distribution and species diversity. By combining data from invertebrate monitoring with data on weather, vegetation and perhaps terrestrial vertebrates, the park will have a rare opportunity to evaluate fluctuations and long-term changes in invertebrate populations at a level of detail rarely achieved.

MONITORING DESIGN CONSIDERATIONS

DIFFICULTIES IN MONITORING INVERTEBRATES

For most terrestrial invertebrates, it is difficult and expensive, in terms of time and labor, to assess absolute densities. This is especially true given the potentially wide variability between local habitat patches as well as the oftentimes high seasonal variability. For this reason, we did not attempt to incorporate methods in the monitoring program which could provide density estimates (e.g. mark-recapture techniques or exhaustive counts.)

In addition, it was not within the scope of the monitoring program to follow invertebrates throughout their life cycle. For insects in particular, differences between life cycle stages are frequently great enough that different habitats must be sampled and different methods used to obtain estimates of numbers. Such studies of even single species are potentially full-time projects. Therefore, the monitoring program does not provide a broad spectrum of information on individual species population dynamics.

Terrestrial invertebrate populations may undergo extreme fluctuations, either seasonally or from year to year. The highly seasonal occurrence of particular invertebrate species poses problems for monitoring. We have attempted to deal with this in the selection of species on which the monitoring program concentrates, as well the timing of the sampling periods. Marked annual variability will make it difficult to detect long-term trends. Given the context of the overall park monitoring program, however, it may be possible to account for such variability in terms of measured trends in weather and island plant communities.

Invertebrate numbers may vary markedly across different microhabitats, and an adequate number of samples to average across such variability would have been prohibitively expensive and time-consuming. Some of our methods (e.g. light and malaise traps) attract insects or take active wide-ranging insects and should not be as susceptible to problems of spatial variability. The board transects cover a wide area and thus sample across such spatial variability. Sweep and vacuum samples are replicated within a single habitat in a few instances, but are most likely to suffer from this sort of spatial variability.

A more basic consideration to the monitoring program has been how to interpret the data collected and elucidate patterns and trends in the large, complex invertebrate community. Some monitoring studies rely on the concept of the "indicator species." However, the indicator species idea has been questioned and, for the island invertebrates, we do not have sufficient data to analyze the relationship between a trend in one species and trends in other species in the community. Hence we are faced with trying to track and interpret changes in a very large number of species individually.

Our solution to this basic problem has been a two-part approach to monitoring the island invertebrates. Snail populations (which are of particular interest because of their endemic status and, in some cases, rarity) are studied relatively intensively, using methods and a schedule of sampling intended to provide specific information on trends in distribution and numbers.

A variety of general techniques, on the other hand, will be used to gather data on numbers and distribution of the range of other invertebrate species. These data will be available for analysis of trends within individual species (particularly for certain "target species" as discussed below). However, the primary use of the data will be to calculate an index which will give indication of trends within the invertebrate assemblage as a whole. The measure used is the Shannon-Wiener index, which incorporates data on both number of species and relative abundance (see Ricklefs 1979). This index is most appropriate for analyzing random samples of an entire community. Typically such samples will miss some of the rarer species, but the absence of a few rare species has little effect on the final index value (Brower and Zar 1977). Such an index provides a view "of the behavior of the community treated as an entity" (Pielou 1974).

By using a variety of general collecting techniques, the park can evaluate the diversity of day- and night-flying (malaise and light traps), ground-dwelling (cover boards) and foliage-dwelling (sweep and vacuum samples) invertebrates. Additionally, specific species, including snails and representatives of the major insect orders, have been selected for more detailed monitoring of abundance and distribution. These target species are shown in Appendix 2 along with the other terrestral invertebrates known from Anacapa, San Miguel and Santa Barbara Islands.

POPULATION DYNAMICS PARAMETERS MONITORED

Based on the above considerations, we have selected the following measurements for monitoring invertebrates:

1. **Abundance.** The number of individuals for each target species will be used to track changes in abundance, dominance, presence or absence of these species in particular habitats.

2. **Distribution.** The island-wide distribution of target species will be monitored to detect expansion (or contraction) of the species' known range. Additionally, the local distribution of snails will be monitored to document shifts related to changes in local vegetation.

3. **Species diversity.** The Shannon-Wiener index of species diversity (Pielou 1974) will be used to measure overall community trends for each sampling technique. In addition, data will be subdivided for native versus non-native species to detect trends in the proportion of native invertebrates on the islands.

4) **Snail size/age structure.** Four species of snails will be measured to track age structure and annual recruitment for rare snails on Santa Barbara Island.

These aspects of invertebrate population dynamics can be monitored with a reasonable amount of funding and personnel and will at the same time provide a variety of data to assess changes in the invertebrate community.

COLLECTING METHODS

Invertebrates will be monitored using a variety of sampling techniques, including artificial cover boards, light traps, malaise traps, sweep samples and vacuum samples. Cover boards will sample snails and ground-dwelling arthropods; light traps will sample night-flying insects (primarily moths); malaise traps will sample day-flying insects; and sweep and vacuum samples will sample arthropods on plants. These techniques will be employed at one to several sites across the range of both native and non-native plant communities on all three islands.

A number of standard invertebrate sampling techniques have not been utilized in this monitoring program. These methods were considered and rejected for a variety of reasons. Pitfall traps consisting of plastic gallon jars sunk level with the ground and covered with plywood lids were extensively tested. While they were effective in capturing many species of ground-dwelling invertebrates, they generally sampled the same species as the boards. Pitfall traps, however, were more time-consuming to use, needed regular maintenance and had to be opened for a specific length of time. Boards, on the other hand, required little or no maintenance and could be checked at any time without the need to open and close traps. Visual searches for snails were conducted by systematically walking along a designated route during periods when snails were active. While it proved possible to assess snail activity and relative numbers in this manner, the technique was obviously biased toward the larger species and inevitably led to some individuals being trampled in the dense vegetation.

Water traps (trays of water set out to passively trap flying insects and other invertebrates) were tested on all islands. Results from these traps were variable, with some traps collecting good samples and others collecting little or nothing. In some instances, most of the sample consisted of human-associated species such as the Calliphorid fly, *Phaenicia sericata*. Also, we had a few problems with lizards or mice getting into the traps. Because of the variability of the samples, the potential hazard to some of the island mammals and reptiles, and the species sampled by water were also sampled by other methods (e.g. malaise), we did not include this method in the monitoring program.

We also tested sticky traps, which trap insects on an adhesive surface similar to flypaper. However these traps pose a hazard to birds, so we abandoned this technique as well.

As part of the design portion of the study, 1/4 inch plywood and both 2-inch and 4-inch thick boards were tested for use as cover. All artificial cover types harbored some species of invertebrates, especially in the cooler, wetter times of year. Two-inch thick boards were superior to plywood in their ability to retain moisture and provide a more stable temperature environment for invertebrates. The 4 in. boards were also superior to plywood, but they were not obviously better than 2 in. boards. For this reason, we have replaced all the plywood with 2 in. pieces of fir and recommend that 2 in. boards be used for all monitoring.

DISTRIBUTION OF SAMPLING SITES

Sampling sites were selected in the major habitats on the three islands, following the community designations of Hochberg et al. (1979). When possible, sampling sites were established near other monitoring sites, especially the plant transects. By using established sites, fewer stakes were required in the field. The close association with plant transects will greatly enhance the usefulness of the invertebrate data by allowing the park to analyze invertebrate trends with respect to changes in vegetation.

SAMPLING SCHEDULE AND PERSONNEL

Invertebrate populations vary in their seasonal abundance patterns. Some, notably many of the ground-dwelling species occurring under boards, maintain their numbers through most of the year.

Other species have a very short period when they are active and available for sampling. Compounding the problem of short activity season, the "season" may occur at different times from year to year.

Our selection of sampling dates for the different collecting techniques were based primarily on such problems of séasonal and annual variability. Given the range of techniques and target species, we selected sampling periods which covered the part of the year when species of interest were active (or, for species active year-round, the period when activity or numbers were apparently greatest). Boards, for example, could be sampled over a relatively long period of time, whereas malaise samples were more restricted to particular periods when the target species were flying. Time periods were selected based on the sampling we conducted during our two years of field work on the islands.

It is our expectation that the monitoring program can be carried out by one full-time entomologist with the assistance of a part-time (0.5 - 0.8 FTE) field technician.

TARGET SPECIES

A number of target species were selected to highlight year-to-year changes in island invertebrate populations (Table 4). Factors considered in selecting the example species were as follows:

1. **Special interest species**--endemic, rare, or sensitive to disturbance;

2. **Species considered to be ecologically important**, particularly pollinators, generalist predators, and generalist herbivores;

3. **Species which are important food for special-interest vertebrate species** (e.g. Jerusalem Crickets, important food for island foxes);

4. **Introduced species**, particularly when numerous or when becoming numerous (e.g. isopods, earwigs).

Some potential target species were not selected for various reasons. Generally, these fell into the following categories:

1. **Species restricted to specific host plants or habitats** (welfare tied to a specific host plant or habitat--monitoring of that habitat suggested);

2. **Species too poorly known for monitoring**--in general, species which we did not pick up with any of the sampling methods we tested;

3. **Species which would require specialized methods specifically for them** (e.g. the endemic grasshopper, *Trimerotropis,* on Santa Barbara Island, and the cactus scale, *Dactylopius*, on Anacapa);

4. **Species of limited occurrence/importance** (e.g. aquatic invertebrates).

CURATION AND IDENTIFICATION OF INVERTEBRATES

Unlike other groups included in the Channel Islands National Park monitoring program, many of the terrestrial invertebrates cannot be identified to species level (even by an experienced entomologist) using standard reference and taxonomic literature. Standard works on insect and other terrestrial invertebrate identification generally allow determination only to the level of family, subfamily or tribe. Further, even for those groups where they are available, detailed keys to species are frequently beyond the ability of a general entomologist. For this reason, the voucher collection and accompanying notes provided to the park, along with this handbook, will be the primary resource for identification of invertebrates collected in the course of the monitoring. The references listed in Appendix 3 allow for tentative identification of unknown species (to family or occasionally lower taxonomic level) as well as providing additional information on identifying characteristics, morphology and ecology of the species known to occur on the park islands.

Final determination of unknown species collected in the course of monitoring will, in many cases, have to await examination of the specimens by experts in the particular group. Additional specimens collected during the Invertebrate Monitoring Design Study have been deposited in the collections of the Natural History Museum of Los Angeles County and the Santa Barbara Museum of Natural History. Experts at these institutions may be able to provide assistance with unfamiliar species found on the islands. In addition, Appendix 3 lists taxonomists who have a professional interest in the park islands, and who may be willing to examine new material.

Because of the importance of voucher specimens to the monitoring program, the park collection must be maintained in good condition. New specimens must be handled carefully and mounted or preserved as soon as possible (see Borror et al. 1976 and Martin 1977 for guidelines on mounting and preservation techniques). Collection data should be recorded accurately and should always be kept with the specimens. Fieldwork for the monitoring is time-consuming and taxing, but adequate time must be allowed for curation of specimens or the information collected will lose much of its value. We have listed some of the more useful references and necessary equipment in Appendix 4.

MONITORING PROTOCOL

DATA COLLECTION

Appendix 5 shows the sampling schedules for each technique. The X's indicate which techniques are to be used each month. Unless otherwise noted, an X applies to all three islands. For example in June, light trapping, malaise trapping, sweep sampling and vacuum sampling will be conducted on all three islands. In August, light trapping and sweep samples will be conducted on all three islands. In April, cover boards are checked on Anacapa and San Miguel Islands (but snails are not measured) and malaise trapping is done on all three islands.

Assuming that the islands cannot be sampled concurrently because of personnel/scheduling limitations, we recommend that Santa Barbara Island be sampled first, as the season is generally shorter on that island.

Cover Boards

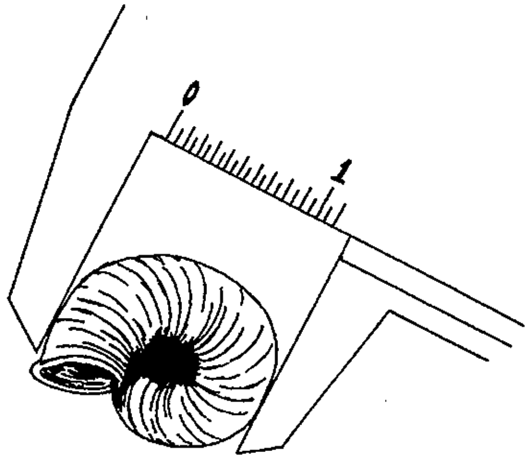
Artificial cover boards are used to count snails and ground-dwelling arthropods. Boards have been deployed in transects which generally consist of 60 boards arranged in two rows of 30. The rows are 5 m apart and the spacing between boards in each row is 5 m (spacing in some habitats is approximate). The end board in each row is marked with a metal tag with the board number (e.g. 1, 30, 31 or 60). The other boards are not numbered. Deviations from the standard arrangement of boards are discussed for specific transects in Appendix 6.

Transects are checked by quickly lifting each board and counting the invertebrates underneath. Check the ground first and then the bottom of the board. The individuals on the ground are more likely to escape and not be counted than those on the board. Unfamiliar species should be captured for later identification or verification. Use an aspirator or, for larger species, a small jar for capturing invertebrates. The litter and ground under the board should be examined, but it should not be disturbed to such an extent that the microhabitat under the board is significantly altered (i.e. do not sweep the litter away or toss it to the side).

Snails are measured as shown in Figure 1. Small snails should be handled carefully to avoid damaging their shells. Also, avoid jarring snails which are sealed to the underside of the board. If two people are checking the transect, one should check the boards and the other should record the data. If you are working alone, use a portable tape recorder to record observations. Looking away to write notes, even momentarily, can make it difficult to keep track of which individuals have been counted.

After checking under a board, replace it carefully. The board should lie directly on the ground and not be held up by vegetation or small rocks. Any snails which are attached to the underside of the board should not be disturbed; take care to lay the board down so that the snails are not harmed or jarred from their attachment.

Figure 1. Snail measurement



The conditions for checking boards differ with the season. Winter samples are conducted primarily for snails. Hence December, January and February samples need to be conducted after there has been at least 1.5 cm of rain in the preceding month. Do not check boards when it is unusually dry (e.g. during or immediately after Santa Ana conditions). Boards on Santa Barbara Island should be checked between noon and 4 p.m. when the ground is dry and snails are inactive. Do not check boards or walk along the transects in either the canyons or the *Coreopsis* areas on Santa Barbara Island if it is raining or if the vegetation is damp. Snails will be active and could easily be stepped on and crushed. Winter sampling conditions must meet the following minimum criteria:

Rain	1.5 cm in the preceding 4 weeks
Temperature	Not unusually hot
Wind	--
Fog	--

Spring sampling conditions must meet the following minimum criteria:

Rain	None
Temperature	Not unusually hot or dry
Wind	--
Fog	--

Appendix 5 shows the schedule for trapping on each island and Figures 2, 3 and 4 show the locations of sampling sites for each island. Record the board number, species, number of individuals and comments on the data form in Appendix 7 as shown in Appendix 8. Species which can readily be identified should be counted on the ground or on the underside of the board. Representatives of unfamiliar species should be collected and mounted for later identification. Care must be taken not to allow any individuals to escape.

Special Considerations

The island night lizard is a federally-listed species which will be found under boards on Santa Barbara Island. Any lizards which are encountered should simply be allowed to retreat to other cover. Do not attempt to capture or otherwise disturb them. Capturing island night lizards not only requires a federal permit, but also can result in the lizard losing its tail, which can affect both its survival and reproduction.

Since vegetation can grow over boards and obscure them, carry a walking stick or pole to tap the ground in the vicinity of boards that you cannot find. This technique is much more efficient than searching through the vegetation by hand.

Boards occasionally crack and break apart with age. Replace these boards immediately since a broken board does not provide nearly as good shelter and the data are not comparable. Carry 2 to 3 extra boards when checking transects to replace any broken boards found. Also, in some areas such as the grasslands on San Miguel Island, the ground cracks and forms a depression under boards after a few years. When this happens, move the board a foot or two so that the ground underneath is more uniform.

Black widow spiders are rare, but present on San Miguel Island. Though we never found black widows under the cover boards, they could show up there occasionally. Lift the boards by the edge and do not reach underneath without looking first.

Light Traps

Light traps are used to sample night-flying insects. The traps used for monitoring are a standard design which includes a rain cover, a circular ultraviolet fluorescent tube and a metal funnel to retain insects drawn to the light. Power is provided by a 12-amp/hour gel cell. The gel cell will run the trap for one night and can be recharged from a solar panel or any 110 volt source. Recharging from a solar panel may take as long as 48 hours. The trap is set at dusk and allowed to run all night. Set the trap out of the wind, but in a place where it can be seen from a long distance. Position the trap on a flat, solid surface so that it is stable enough to withstand occasional gusts of wind. Weather conditions will affect the number of insects caught. Skies may be either clear or overcast, but dense fog, strong winds or rain are not acceptable.

Nights for light trapping must meet the following minimum criteria:

Rain	Not raining when the trap is set, no heavy rain predicted for the night
Temperature	Not unseasonably cold
Wind	Less than 10 knots
Fog	At least 500 meters visibility

Appendix 5 shows the schedule for trapping and Figures 2, 3 and 4 show the locations of the sampling sites for each island. Data are recorded on the form in Appendix 9 as shown in Appendix 10. Insects in the trap are either caught with an aspirator (small specimens) or directly into a small killing jar (larger specimens). Species which can readily be identified should be counted and released. Representatives of all other species should be collected and mounted for later identification. Care must be taken not to allow any insects to escape.

Special Considerations

We used standard 40- 50-amp/hour car batteries to run light traps, but we recommend the much smaller and lighter gel cells for the monitoring program. A car battery will run for 3 to 4 nights, but the number, size and weight of car batteries becomes impractical when a number of traps must be run on one night in remote parts of the islands. Also, getting a car battery on and off of Middle and West Anacapa is difficult and potentially dangerous.

Gel cell rechargers (120 v) are commercially available, but an adaptor must be constructed to recharge directly from a solar panel. Appendix 4 gives the source for light traps.

Malaise Traps

Malaise traps are used to sample flying insects. These traps consist of several panels of fine nets which are deployed in an "H" pattern, when viewed from above, with a tent-like net covering the top. Insects fly into the vertical panels and move up into a collecting jar which is placed at the high end of the trap.

Malaise traps are set for three hours. Since it often gets increasingly windy during the day, traps must be set by 9 a.m. The most important considerations in selecting a location for the trap are wind, lay of the land and distribution of local vegetation. If there is any wind, the trap must be set with the long dimension parallel to the wind and the low end of the trap (without the collecting jar) facing into the wind. If there is a slope, the end with the collecting jar must be at the upper end. If there are shrubs at the sample site, the trap should be placed in a likely flight lane for insects (e.g. blocking an opening between shrubs, or perpendicular to the course of a gully).

The collecting jar should be loosely filled with 3 to 4 squares of slightly crumpled toilet paper to provide a place for insects to sit and reduce interactions which might damage specimens. Specimens can be killed either by using an ethyl acetate impregnated lid on the collecting jar or by placing the collecting jar in the freezer after the sample is collected. Care must be taken not to allow any insects to escape. Malaise trapping must meet the following minimum criteria:

Rain	None
Temperature	Not unusually cold
Wind	Less than 10 knots
Fog	At least 2 km visibility

Appendix 5 shows the trapping schedule for each of the islands and Figures 2, 3 and 4 show the locations of sampling sites for each island. Data are recorded on the form in Appendix 9, as shown in Appendix 10. Representatives of unknown species should be mounted or preserved in alcohol for later identification.

Special Considerations

The panels of the trap must be taut and well-staked. If not, they are likely to pull loose and generally make the trap less effective. If the trap is not well-staked, it is more likely to be ripped or otherwise damaged by the wind.

Trapping in winds of 10 knots or more not only will yield poor samples that are unacceptable for the monitoring program, but also may cause serious damage to the trap. Appendix 4 gives the source for commercial malaise traps.

Sweep Samples

Sweep samples are collected by using an insect net to sweep invertebrates from the surface of vegetation. Sweeping is superficially the most straight-forward technique, but there are several important considerations that must be kept in mind to achieve comparable samples. Each sample consists of 50 sweeps of the net while slowly walking in one direction. Each sweep should encompass about 160o. The net should firmly brush the vegetation, but not to the point of thrashing the plants. There may be a small accumulation of leaves and small twigs in the net. A typical sample will be completed while traveling 35 - 40 m.

Keep the net moving during the entire course of the sample so that the more active individuals are not able to escape. As the last sweep is completed, fold the net bag around the hoop to trap the specimens inside. Transfer the contents of the net to a large, wide-mouthed jar. Add a label to the jar describing the location and vegetation sampled.

Samples are easiest to sort if they are placed in a refrigerator first. Once the sample is cold, it can be dumped into a freezer tray for sorting. If the invertebrates become too active, cover the tray with the lid and return it to the refrigerator.

Sweep sampling can be conducted in a somewhat broader range of conditions than most of the other techniques. Generally, samples can be collected from 9 a.m. to 3 p.m., though the vegetation must be dry and the middle of the day should be avoided if it is particularly hot. Sampling conditions must meet the following minimum criteria:

Rain	None, vegetation dry
Temperature	Not unusually cold or hot
Wind	Less than 20 knots
Fog	Vegetation dry

Each sample must include a list of the major plant taxa sampled since many of the species are associated primarily with particular types of vegetation. The schedule for sampling is shown in Appendix 5, and Figures 2, 3 and 4 show the sampling sites for each island. Data are recorded on the form in Appendix 9, as shown in Appendix 10. Species which can readily be identified should be counted and released. Representatives of all other species should be mounted for later identification. Some insects are likely to escape during sorting, but try to minimize this as much as possible.

Special Considerations

None

Vacuum Samples

A vacuum sampler is used to suck small invertebrates off vegetation. Vacuum samples are collected using a commercial vacuum sampler (D-Vac) which consists of a small gasoline engine (originally designed as a leaf blower) with a bellows, funnel and collecting bag.

Before assembling the D-Vac, make sure it has sufficient fuel (gas/oil mixture) as it is difficult to add gas once the sampling apparatus is attached. Attach the bellows first and then place a collecting bag on the rim of the bellows. Attach the funnel over the end of the bellows. The assembly of the vacuum is not particularly obvious, so you should have the instructions available the first few times you use the sampler. Once the sampler is assembled, it can be transported to the collection site either by hand or on a pack frame. Once on site, put on hearing protection and start the motor. Sampling consists of vacuuming shrubby vegetation for 2 minutes. It is generally possible to vacuum an area of about two square meters or 10 to 15 branches of a shrub like *Coreopsis* during a 2-min. period. If you spend a significant amount of time moving between plants, add an appropriate amount of time to the sampling period.

Samples are collected by placing the funnel over the plant (or branch, if the plant is large) and shaking the sampler (and hence the plant) moderately hard so that invertebrates drop off the vegetation and are swept into the collecting bag. Many species do not readily drop off the vegetation, so shaking the plant is necessary to acquire a consistent sample. This technique should not damage the plant, though dead leaves or small branches are invariably drawn into the collection bag.

Keep the vacuum running during the entire sampling period so that individuals do not escape. Do not shut off the vacuum until the collecting bag has been recovered and closed. Add a label (listing the technique, date, location and plant species vacuumed) to the bag so samples are readily identified when you return from the field. Separate collecting bags are required for each sample.

Place the samples in a refrigerator prior to sorting. Once the sample is cold, it can be dumped into a freezer tray for sorting. If the invertebrates become too active, cover the tray with the lid and return it to the refrigerator.

Like sweep sampling, vacuum sampling can be conducted in a somewhat broader range of conditions than most of the other techniques. Generally samples can be collected from 9 a.m. to 3 p.m., though the vegetation should be dry and the middle of the day should be avoided if it is particularly hot.

Sampling conditions must meet the following minimum criteria:

Rain	None, vegetation dry
Temperature	Not unusually cold or hot
Wind	Less than 15 knots
Fog	Vegetation dry

The schedule for sampling is shown in Appendix 5 and Figures 2, 3 and 4 show the sampling sites for each island. Data are recorded on the form shown in Appendix 9. Sample data are illustrated in Appendix 10. Species which can readily be identified should be counted and released. Representatives of all other species should be mounted for later identification. Some insects are likely to escape during sorting, but try to minimize this as much as possible.

Special Considerations

The gasoline motor should be serviced at the beginning of each field season. Before going out to the islands, assemble the entire unit and start the engine to make sure that all parts are present, the unit is in good condition and the engine is working properly.

The gasoline engine is decidedly loud; wear hearing protection. Collect samples only when visitors are not in the area.

Appendix 4 gives the source for commercial vacuum samplers.

DATA INPUT

A dBase III+ computer program has been written to facilitate data entry and analysis. Appendix 11 provides a listing of the program and Appendix 12 gives the structure of the appropriate data files. A copy of the program and data files have been supplied to Channel Islands National Park on a 5 1/4" floppy disk. Additional copies are available from the senior author.

The INVERT.PRG program runs from within dBase III+ and uses the INVERT.DBF, INVERT_L.DBF and SNAIL.DBF files to store data. It has data entry modules for both count data and snail measurements.

Begin the program at the dBase dot prompt by typing: Do Invert

After selecting the appropriate module, the program prompts the user for the same information as on the field data forms. The program automatically enters class, order, family and native/non-native status. If a new species is found, the master list can be edited by selecting the update module and entering the appropriate taxonomic information.

After entering data, print and proofread the data prior to analysis. Editing data files and printing reports are done from within dBase using the dBase EDIT or BROWSE commands.

The invertebrate program does not require any knowledge of dBase, but a limited understanding of dBase is necessary to edit data files and produce reports. Some aspects of the data analysis will require a moderately good understanding of dBase in order to extract and summarize size and distribution data. A professional quality graphics program such as Slidewrite Plus will be needed for plotting data.

Special Considerations

It is critically important to have backup copies of all data and program files. Data files must be backed up whenever data are added and at least once a day when they are being edited.

DATA ANALYSIS

The data are analyzed to evaluate the abundance and distribution of the target species and the diversity of species for each island. In addition, size distribution of snails will be analyzed as an indication of changes in age structure and recruitment.

Abundance of Target Species

Data for each target species are summarized for each island where it occurs, but only for the primary sampling technique(s) indicated in Appendix 2. Hence data for the tenebrionid beetle *Coelus pacificus* are summarized from the cover board data on Anacapa and San Miguel Islands, data for the ant *Monomorium minimum* are summarized from the cover board data for Santa Barbara and San Miguel Islands and data for the moth *Argyrotaenia franciscana* are summarized from the light trap data for Anacapa and San Miguel Islands.

Abundance data are plotted as a histogram of abundance (y-axis) versus site. All sample sites for an island are listed on the x-axis even if the target species was not found there. This allows changes in distribution to be seen when comparing graphs from different years.

A separate graph is prepared for each species for each island. For those few species with more than one technique listed in Appendix 2, a separate set of graphs is prepared for each technique.

Abundance is evaluated by a visual inspection of graphs from each year. Normally this would be done by comparing separate graphs for each year, but it might prove useful to combine years on a single graph with the bars of the histogram coded by year. After more than 3 to 4 years, such clustered histograms are likely to become too cluttered. If it appears that significant changes might be occurring, the data should be evaluated with an analysis of variance.

Distribution of Target Species

Island-wide distributional changes are evaluated using the same set of graphs prepared for the abundance data. By comparing the number of sampling sites where a target species occurs on each island, distributional changes can be noted. A consistent trend in distributional change should be evaluated with respect to other changes which are occurring (e.g. vegetation, weather).

The cover board transects allow distribution to be evaluated on a much finer scale than described above. Summarize the counts for the four target species of snails for each station along the transect. For transects with two parallel rows of boards, pool the data for each of the 30 pairs of boards. Snail distribution is then plotted as abundance (y-axis) versus board number. Separate graphs are prepared for each species of snail for each transect. As with the island-wide distribution data, indications of significant changes in distribution for any of the snails should be evaluated with respect to major factors which might be affecting them. Significant downward trends would warrant consulting biologists who are familiar with the snails of the Channel Islands.

Species Diversity

Species diversity is calculated using the Shannon-Wiener index:

$$H = -\mathrm{sum}(pi * \log e\ (pi))$$

where *pi* is the proportion of the total number of individuals occurring in species i. While the logarithmic base is not important, it must be consistently applied. We have standardized on base e, the natural log. Since some researchers have used base 2 or 10, the logarithmic base must be specified when reporting measures of diversity.

For the diversity index to work properly, it is essential that all invertebrates be identified to the species level, though it is not important that the "real" name of a taxon is known. For example, it is quite acceptable to use *Lacinipolia* sp1, *Lacinipolia* sp2, etc.

Diversity indices are calculated for each technique (cover boards, light traps, malaise traps, sweep samples and vacuum samples) for each island. These calculations are then repeated for both native and non-native species for each technique.

If changes in diversity are noted, appropriate statistical comparisons should be made to document whether or not they are significant. Significant changes should be studied further to determine the cause. Data on weather and vegetation are likely to be important in understanding changes in invertebrate populations.

Snail Size Distribution

Plot snail shell lengths as a histogram with number of individuals (y-axis) versus size class. Make a separate graph for each transect, species and season. The graphs are examined for trends in size distribution. While shifts in size class data can signal important changes in the population structure, the interpretation of these data is difficult (Deevey 1947, Caughley 1974). The size data are intended primarily to supplement the data on relative numbers and distribution and to provide additional information for interpreting any changes seen.

ANNUAL REPORT

An annual report summarizing the results of the invertebrate monitoring should include a table that lists the number of each species collected and counted at each sampling site on each island. Appendix 13 shows the appropriate format for the table. Tabulating the data in this format will provide a summary that can be used by specialists to evaluate trends in species of particular interest.

Special Considerations

Samples which are not collected in standard fashion do not allow for valid comparisons with other samples. It is critically important that the guidelines for each technique be carefully followed.

One of the problems that can arise, in spite of the best intentions, is incomplete samples, e.g. malaise traps that were not deployed for the full length of time or missing cover boards. These problems must be dealt with differently depending on the technique. Cover board samples can be extrapolated to the full count if at least 80% of the boards are actually checked. If cover boards are not found, they should be replaced. It is not acceptable to routinely sample 80% of the boards and then extrapolate.

Light, malaise, sweep and vacuum samples cannot be used if they were not collected for the proper length of time. The reason for this is that insects would not be expected to be captured at a constant rate. Therefore, extrapolations would skew the results.

DATA AND MONITORING REVIEW

Biologists specializing in the ecology of rare taxa on the islands (e.g. snails) should be consulted every 3 to 5 years so that population trends can be examined in detail. Changes in abundance, distribution, species diversity and relationships with habitat and other species should be examined.

As the monitoring program matures, the target species being monitored should be reviewed. Changes in abundance and distribution of some species will occur with changes in habitat or in response to events such as fire or the elimination of exotic species. Hence it may be appropriate to add or delete species from the list of target species. Such changes should be made in consultation with biologists familiar with the island invertebrate fauna.

Sampling techniques should also be reviewed after several years of data collection to determine whether each technique is yielding satisfactory results or if a modification is necessary. For example, it would be appropriate to evaluate the number of boards used in the board transects, the number of sweeps in a sweep sample and the number of hours that the malaise traps are deployed. In addition, the invertebrate taxa collected should be reviewed to determine if the techniques are sampling a suitable range of invertebrates or if additional methods should be employed.

LITERATURE CITED

Arnett, Ross H., Jr. 1985. American Insects. A Handbook of the Insects of America North of Mexico. Van Nostrand Reinhold Co. Inc. New York.

Borror, Donald J., Dwight M. DeLong and Charles A. Triplehorn. 1976. An Introduction to the Study of Insects. Holt, Rinehart and Winston. New York.

Borror, Donald J. and Richard E. White. 1970. A Field Guide to the Insects of America North of Mexico. Houghton Mifflin Co., Boston.

Brower, James E. and Jerrold H. Zar. 1977. Field and Laboratory Methods for General Ecology. Wm. C. Brown Co. Pub., Dubuque, Iowa.

Caughley, Graeme. 1974. Interpretation of age ratios. J. Wildl. Manage. 38: 557 - 562.

Covell, C. V. 1984. A field guide to the moths of eastern North America. Houghton Mifflin Co., Boston.

Deevey, E. S., Jr. 1947. Life tables for natural populations of animals. Quart. Rev. Biol. 22: 283 - 314.

Federal Register. 1989. Endangered and threatened wildlife and plants: Animal [sic] notice of review. 54(4): 554 - 579.

Goeden, Richard D., Charles A. Fleschner, and Donald W.Ricker. 1967. Biological control of prickly pear cacti on Santa Cruz Island, California. Hilgardia 38: 579 - 606.

Hogue, Charles L. 1974. Insects of the Los Angeles Basin. Nat. Hist. Mus. L.A. Co., Sci. Series.

Hochberg, F. G., Jr. 1979. VI. Invertebrate Zoology: Land Molluscs. 6.1 - 6.131 pp. In: Power, Dennis M. (ed.) Natural Resources Study of the Channel Islands National Monument, California. Santa Barbara Museum of Natural History, Santa Barbara, California.

Hochberg, Mary, Steven Junak, Ralph Philbrick and Steven Timbrook. 1979. V. Botany. 5.1 - 5.92 pp. In: Power, Dennis M. (ed.) Natural Resources Study of the Channel Islands National Monument, California. Santa Barbara Museum of Natural History, Santa Barbara, California.

Martin, J. E. H. 1977. The insects and arachnids of Canada. Part 1: Collecting, preparing, and preserving insects, mites, and spiders. Canada Department of Agriculture, Publication 1643.

Miller, Douglass R. 1971. Mealybugs of Santa Cruz Island, California (Homoptera: Coccoidea: Pseudococcidae). Pan-Pac. Ent. 47: 293 - 303

Miller, Douglass R. 1973. Mealybugs of San Miguel Island, California (Homoptera: Coccoidea: Pseudococcidae). Pan-Pac. Ent. 49: 264 - 269.

Miller, Scott E. 1979. VII. Invertebrate Zoology: Insects and their relatives. 7.1 - 7.30 pp. In: Power, Dennis M. (ed.) Natural Resources Study of the Channel Islands National Monument, California. Santa Barbara Museum of Natural History, Santa Barbara, California.

Miller, Scott E. 1984a. Butterflies of the California Channel Islands. J. Res. Lepid. 23(4): 282 - 296.

Miller, Scott E. 1984b. Earwigs of the California Channel Islands, with notes on other species in California (Dermaptera). Psyche 91(1-2): 47 - 50.

Miller, Scott E. and W. S. Davis. 1985 (1986). Insects associated with the flowers of two species of *Malacothrix* (Asteraceae) on San Miguel Island, California. Psyche 92(4): 547 - 555.

Miller, Scott E. and Arnold S. Menke. 1981. Entomological Bibliography of the California Islands. Santa Barbara Museum of Natural History, Occasional Paper Number 11.

Miller, Scott E. and Pamela M. Miller. 1985. Beetles of Santa Barbara Island, California (Coleoptera). pp. 121-136 In: Menke, Arnold S. and Douglass R. Miller (ed.). Entomology of the California Channel Islands. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Pielou, E. C. 1974. Population and Community Ecology: Principles and Methods. Gordon and Breach, New York.

Powell, Jerry A. 1985. Faunal affinities of the Channel Islands Lepidoptera: a preliminary overview. pp. 69 - 94 In: Menke, Arnold S. and Douglass R. Miller (ed.). Entomology of the California Channel Islands. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Rentz, David C. F. and David B. Weissman. 1982. Faunal affinities, systematics, and bionomics of the Orthoptera of the California Channel Islands. Univ. Calif. Pub. Ent. 94: xiii + 240 p.

Ricklefs, Robert E. 1979. Ecology. Chiron Press, New York.

Rust, Richard W. 1985. Bees of Anacapa Island, California (Hymenoptera: Apoidea). pp. 117 - 119 In: Menke, Arnold S. and Douglass R. Miller (ed.). Entomology of the California Channel Islands. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Rust, Richard W., Arnold S. Menke, and Douglass R. Miller. 1985. A biogeographic comparison of the bees, sphecid wasps, and mealybugs of the California Channel Islands (Hymenoptera, Homoptera). pp. 29 - 59 In: Menke, Arnold S. and Douglass R. Miller (ed.). Entomology of the California Channel Islands. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Stephen, W. P., G. E. Bohart, and P. F. Torchio. 1969. The biology and external morphology of bees. Oregon State University, Corvallis, Oregon.

Table 1. Terrestrial Invertebrates known from Anacapa, Santa Barbara and San Miguel Islands in 1979 (Hochberg 1979; Miller 1979) and 1989 (present study).

Island	1979	1989
Anacapa		
Snails	2	2
Insects	94	130
Other Arthropods	3	7
Total	99	139
Santa Barbara		
Snails	6	7
Insects	105	146
Other Arthropods	16	23
Total	127	176
San Miguel		
Snails	2	2
Insects	167	179
Other Arthropods	17	20
Total	186	201
Grand Total	412	516

Table 2. Number and proportion of endemic taxa on Anacapa, Santa Barbara and San Miguel Islands.

	Species	Total Endemic	Percent
Anacapa			
Snails	2	1	50
Arthropods	137	18	13
Santa Barbara			
Snails	7	6	86
Arthropods	169	14	8
San Miguel			
Snails	2	1	50
Arthropods	199	22	11

Table 3. Federal Category 1 species requiring full protection by the National Park Service.

Common Name	Scientific Name	Family	Islands
Globose dune beetle	*Coelus globosus*	Tenebrionidae	ANI, SMI
Slug snail	*Binneya notabilis*	Arionidae	SBI
Concentrated snail	*Micrarionta facta*	Helminthoglyptidae	SBI

Table 4. Orders of terrestrial arthropods found on Anacapa, Santa Barbara and San Miguel Islands[1].

Order	Common Name	Monitor	Notes [2]
Scorpionida	Scorpions	Yes	
Pseudoscorpionida	Pseudoscorpions	Yes	
Phalangida	Harvestmen	Yes	
Acari	Mites, Ticks	No	a b c
Araneida	Spiders	Yes	d
Polyxenida	Millipedes	No	e
Lithobiomorpha	Centipedes	Yes	
Geophilomorpha	Centipedes	Yes	
Collembolla	Springtails	No	b
Thysanura	Silverfish	Yes	
Microcoryphia	Bristletails	Yes	
Odonata	Dragonflies	No	a
Orthoptera(1)	Crickets, Jerusalem Cricket	Yes	
Orthoptera(2)	All other species (e.g. Grasshoppers)	No	a
Dermaptera	Earwigs	Yes	
Isoptera	Termites	No	a
Psocoptera	Psocids, Bark Lice	No	b
Mallophaga	Chewing Lice	No	c
Thysanoptera	Thrips	No	b
Hemiptera	True Bugs	Yes	
Homoptera(1)	Hoppers	Yes	
Homoptera(2)	Scale Insects, Aphids	No	a b
Coleoptera	Beetles	Yes	
Strepsiptera	Twisted-winged Parasites	No	a b c
Neuroptera	Lacewings, Dobsonflies, etc.	Yes	
Trichoptera	Caddisflies	No	a f
Lepidoptera	Butterflies and Moths	Yes	
Diptera	Flies	Yes	
Siphonaptera	Fleas	No	a c
Hymenoptera	Bees, Wasps, etc.	Yes	

[1] After Miller (1979) and present study

[2] Key to Notes:

a - not readily captured by methods used in the monitoring
b - small, poorly known and/or difficult to identify
c - specialized parasites, restricted to specific animal hosts
d - excluding web-spinning species (Araneidae) which are not sampled by the methods selected
e - species not found by our sampling methods
f - aquatic

Appendix 1. Endemic, terrestrial invertebrates on Anacapa, Santa Barbara and San Miguel Islands.[1]

	Anacapa	San Miguel	Santa Barbara
Mollusca			
Family Pupillidae			
Sterkia clementina	-	-	X
Vertigo californica subsp. *catalinaria*	-	-	X
Family Helminthoglyptidae			
Helminthoglypta ayresiana	X	X	-
Micrarionta facta	-	-	X
Xerarionta tryoni	-	-	X
Family Haplotrematidae			
Haplotrema duranti	-	-	X
Family Arionidae			
Binneya notabilis	-	-	X
Arthropoda (Arachnida)			
Scorpionida: Vejovidae			
Vejovis minimus	X	-	-
Acari: Ixodidae			
Ixodes peromysci	X	-	X
Arachnida: Agelenidae			
Rualena cockerelli	-	X	-
Arachnida: Gnaphosidae			
Drassylus barbus	-	-	X
Zelotes cruz	X	-	X
Arthropoda (Insecta)			
Orthoptera: Acrididae			
Trimerotropis santabarbara	-	-	X
Orthoptera: Tettigoniidae			
Neduba morsei islandica	X	-	

[1] After Miller (1985) and Hochberg (1979)

APPENDIX 1. CONT

	Anacapa	San Miguel	Santa Barbara
Orthoptera: Stenopelmatidae			
Cnemotettix caudulus	-	X	-
Cnemotettix spinulus	X	-	-
Hemiptera: Miridae			
Lopidea nigridea hirta	-	X	-
Homoptera: Cicadidae			
Okanagana hirsuta	X	-	-
Homoptera: Cicadellidae			
Tiaja insula	-	-	X
Coleoptera: Melyridae			
Amecocerus anacapensis	X	-	-
Trichochrous calcaratus	X	-	-
Coleoptera: Coccinellidae			
Scymnus falli	-	-	X
Coleoptera: Tenebrionidae			
Apsena grossa	-	-	X
Coniontis lata	X	X	X
Coniontis santarosae	-	X	-
Eleodes incultus	X	X	-
Eleodes laticollis subsp. *apprimus*	X	X	X
Eusattus politus	-	X	-
Coelus pacificus	X	X	-
Coleoptera: Curculionidae			
Sitona cockerelli	-	X	-
Lepidoptera: Arctiidae			
Arachnis picta insularis	X	-	-
Lophocampa indistincta	X	-	-
Lepidoptera: Tortricidae			
Argyrotaenia franciscana subsp. *insulana*	X	X	-
Argyrotaenia isolatissima	-	-	X

APPENDIX 1. CONT

	Anacapa	San Miguel	Santa Barbara
Diptera: Asilidae			
Efferia anacapai	X	-	X
Stenopogon neojubatus	X	X	X
Hymenoptera: Formicidae			
Aphaenogaster patruelis	-	-	X
Camponotus bakeri	-	-	X
Hymenoptera: Sphecidae			
Bembix americana hamata	-	X	-
Palmodes insularis	X	X	-
Hymenoptera: Andrenidae			
Perdita layiae layiae	-	X	-
Hymenoptera: Halictidae			
Dialictus cabrilli	-	X	-
Dialictus megastictus	-	X	-
Dialictus pilosicaudus	-	X	-
Dialictus punctiferellus	-	X	-
Evylaeus hammondi	-	X	-
Sphecodes nigricans subsp. *miguelensis*	-	X	-
Hymenoptera: Anthophoridae			
Anthophora californica subsp. *erysimi*	-	X	-
Total	**19**	**23**	**20**

Appendix 2. Terrestrial invertebrates on Anacapa, Santa Barbara and San Miguel Islands.

		Species	Island AI	SB	SM
Mollusca					
Stylommatophora					
	Arionidae	*Binneya notabilis**	-	X	-
	Haplotrematidae	*Haplotrema duranti**	-	X	-
	Helminthoglyptidae	*Helminthoglypta ayresiana**	X	-	X
		*Micrarionata facta**	-	X	-
		*Xerarionta tryoni**	-	X	-
	Limacidae	*Milax gagates*	X	-	-
	Pupillidae	*Sterkia clementina**	-	X	-
		*Vertigo californica**	X	X	X
	Succineidae	*Succinea* sp.	-	X	-
	Zonitidae	*Pristiloma shepardae**	X	-	-
Chilopoda					
Lithobiomorpha					
	Lithobiidae	*Anthopolys xanti**	-	-	X
Undertermined					
	Undertermined	Undetermined sp.*	X	X	-
Diplopoda					
Polyxenida					
	Polyxenidae	*Polyxenus anacapensis**	X	-	-
Arachnida					
Scorpionida					
	Undertermined	*Vejovis minimus thompsoni**	X	-	-
Pseudoscorpionida					
	Cheliferidae	Undetermined sp.	-	X	-
	Chernetidae	*Dinocheirus* sp.*	X	-	-
	Garypidae	*Garypus californicus**	-	X	X
	Olpiidae	*Serianus* sp.*	-	X	-
Phalangida					
	Phalangidae	*Protolophus tuberculatus**	-	X	X
Acari					
	Bdellidae	*Bdella* sp.	-	X	-
	Belbidae	Undetermined sp.	-	X	-

*Target species in the monitoring program

Appendix 2. Cont.

		Species	Island AI	SB	SM
	Eupodidae	*Tydeus* sp.	-	X	-
	Ixodidae	*Ixodes peromysci*	-	X	-
	Ixodidae	*Haemaphysalis chordeilis*	-	X	-
	Ixodidae	*Haemaphysalis leporispalustris*	-	X	-
Araneida					
	Agelenidae	*Agalena* sp.*	-	-	X
		Rualena sp.*	-	X	-
		Tegenaria derhami	-	-	X
	Araneidae	*Metepeira gosoya*	-	-	X
		Metepeira sp.	X	X	X
	Clubionidae	*Anyphaena* sp.	-	-	X
	Dictynidae	*Dictyna calcarata**	-	-	X
	Dysderidae	*Segestria pacifica*	-	-	X
	Gnaphosidae	*Drassylus apachus**	-	-	X
		*Drassylus barbus**	-	X	-
		Drassylus sp.*	-	-	X
		*Zelotes cruz**	-	X	X
	Lycosidae	*Tarentula kochi**	-	-	X
	Salticidae	*Epiblemum scenicum*	-	X	-
		Habronattus hutchinsoni	-	X	-
		*Metacyrba taeniola**	X	X	-
		*Phidippus formosus**	X	X	X
		Salticus scenicus	-	X	-
	Theridiidae	*Crustunlina borealis*	-	-	X
		Latrodectus hesperus	-	-	X
		Steatoda - near *medialis*	-	X	-
	Thomisidae	*Coriarachne utahensis**	-	X	-
		Philodromus chamisis	-	X	-
		Philodromus sp.	-	-	X
		*Xysticus montanensis**	-	-	X
	Zoropsidae	*Lutica* sp.	-	X	X
Insecta					
Collembola					
	Poduridae ?	Undetermined sp.	-	X	-
	Sminthuridae	Undetermined sp.	-	X	-
Microcoryphia					
	Machilidae	*Neomachilis* sp.*	-	-	X
Thysanura					
	Lepismatidae	*Allacrotelsa spinulata**	X	X	X

	Species	Island		
		AI	SB	SM
Odonata				
Aeshnidae	*Aeshna multicolor* ?	X	X	-
	Anax junius ?	-	X	-
Coenagrionidae	Undetermined sp.	-	X	-
	Undetermined sp.	-	X	-
Libellulidae	*Sympetrum corruptum*	-	X	-
Orthoptera				
Acrididae	*Camnula pellucida*	-	X	X
	Melanoplus cinereus	X	-	-
	Melanoplus devastator	-	-	X
	Microtes occidentalis	-	-	X
	Trimerotropis pallidipennis	X	X	-
	Trimerotropis santabarbara	-	X	-
Gryllacrididae	*Ceuthophilus californianus**	-	-	X
	Cnemotettix caudulus	-	-	X
	Cnemotettix spinulus	X	-	-
	Pristoceuthophilus pacificus	X	-	-
	Pristoceuthophilus sp.	-	X	-
	*Stenopelmatus fuscus**	X	-	X
Gryllidae	*Gryllus* II*	X		-
	Gryllus III	X	X	-
	Gryllus IV	-	X	X
	*Hoplosphyrum boreale**	X	-	-
	Myrmecophilus oregonensis	X	-	X
	Oecanthus argentinus	X	X	-
Mantidae	*Litaneutria minor*	-	X	-
Tettigoniidae	*Neduba morsei*	X	-	-
	Scudderia mexicana	X	-	-
Dermaptera				
Forficulidae	*Forficula auricularia**	-	X	-
Isoptera				
Undetermined	Undetermined sp.	X	X	X
Psocoptera				
Undetermined	Undetermined sp.	X	X	X
Mallophaga				
Undetermined	Undetermined sp.	-	X	X
Thysanoptera				
Aeolothripidae	*Frankliniella occidentalis*	-	X	-
Phlaeothripidae	*Leptothrips mali*	-	X	-
Thripidae	*Anaphothrips* sp.	-	X	-

Appendix 2. Cont.

		Species	Island AI	SB	SM
Hemiptera					
	Anthocoridae	*Anthocoris* sp.	-	X	-
		*Orius tristicolor**	-	X	-
	Lygaeidae	*Emblethis* ?	-	X	-
		Geocoris sp.*	-	X	-
		Lamprodema maura	-	X	-
		*Nysius raphanus**	-	X	-
	Miridae	*Creontiades rubrinervis*	-	X	-
		Deraeocoris sp.	-	X	-
		Lopidea hirta	-	-	X
		Lygus sp.*	-	X	-
	Nabidae	*Nabis americoferus*	X	-	-
	Pentatomidae	*Dendrocoris* sp.	-	X	-
		Euschistus conspersus	-	X	-
		Thyanta sp.	-	X	-
	Reduviidae	*Empicoris* prob. *rubromaculatus**	-	X	-
		Zelus tetracanthus	-	X	-
	Rhopalidae	*Liorhyssus hyalinus*	-	X	-
	Undetermined	*Macroporus repetitus*	-	X	-
Homoptera					
	Aphididae	*Macrosiphum pisi*	-	-	X
	Chermidae	*Aphalara suaedae*	-	X	-
	Cicadellidae	*Deltocephalus punctatus**	-	-	X
		Deltocephalus sp.*	-	X	-
		*Tiaja insula**	-	X	-
		Xerophloea vanduzeei	X	-	-
	Coccidae	*Saissefia oleae*	-	-	X
	Dactylopidae	*Dactylopius opuntiae*	X	-	-
	Diaspididae	*Diaspis echinocacti*	-	X	-
	Pseudococcidae	*Amonostherium lichtensioides*	-	-	X
		Chorizococcus abroniae	-	-	X
		Distichlicoccus salinus	-	-	X
		Heteroccus arenae	-	-	X
		Paludicoccus distichlium	-	-	X
		Phenococcus colemani	-	-	X
		Phenococcus gossypii	-	-	X
		Pseudococcus obscurus	-	-	X
		Puto echinatus	-	X	-
		Puto yuccae	-	-	X
		Rhizoecus gracilis	-	-	X
		Spilococcus keiferi	-	-	X
		Tridiscus distichlii	-	-	X
		Trionymus smithii	-	-	X

Appendix 2. Cont.

	Species	Island AL	Island SB	Island SM
Neuroptera				
Chrysopidae	Undetermined sp*.	X	X	X
Hemerobiidae	*Hemerobius* sp.*	X	X	X
Coleoptera				
Alleculidae	*Isomira comstocki*	-	X	-
Anobiidae	*Ernobius* sp.	-	X	-
	Xestobium marginicolle	-	X	-
Carabidae	*Amara* sp.*	X	X	-
	*Calathus ruficollis**	X	-	X
	Calosoma semilaeve	-	X	-
	*Pterostichus menetriesi**	-	-	X
Cerambycidae	*Callidiellum rufipenne*	-	X	-
	*Ipochus fasciatus**	-	X	X
Chrysomelidae	*Altica* sp.	X	-	-
	Diabrotica undecimpunctata	-	X	-
	Epitrix sp.	X	-	-
	*Monoxia sordida**	-	X	-
	Phaedon prasinella	-	X	-
Cicindelidae	*Cicindela oregona*	-	-	X
Cleridae	*Cymatodera* sp.	X	X	-
	Necrobia rufipes	-	-	X
Coccinellidae	*Coccinella californica**	X	X	-
	*Coccinella johnsoni**	-	X	-
	*Coccinella novemnotata franciscana**	-	-	X
	*Cycloneda sanguinea**	X	-	-
	*Hippodamia convergens**	X	X	-
	*Hippodamia quinquesignata punctulata**	X	-	X
	Scymnus sp.*	-	X	-
Colydiidae	*Rhagodera tuberculata*	-	X	-
Corylophidae	*Aenigmaticum californicum*	-	X	-
Curculionidae	*Anthonomus subvittatus**	-	X	-
	Anthonomus sp.*	-	-	X
	Cleonus sp.	-	-	X
	Listroderes costirostris obliquus	-	-	X
	Listroderes sp.	X	-	-
	Phycocoetes testaceus	-	-	X
	Rhynocolus sp.	-	X	-
	*Sciopithes setosus**	-	X	-
	*Sibinia maculata**	-	X	X
	Sitona cockerelli	-	-	X
	*Trigonoscuta anacapensis**	X	-	-
	Trigonoscuta curviscroba	-	X	-
	*Trigonoscuta miguelensis**	-	-	X

Appendix 2. Cont.

	Species	Island		
		AI	SB	SM
Curculionidae	*Trigonoscuta nesiotis*	X	-	-
	*Trigonoscuta santabarbarae**	-	X	-
Dermestidae	*Dermestes caninus*	-	X	-
	Dermestes frischi	-	X	X
	Trogoderma sternale	-	X	-
Elateridae	*Anchastus cinereipennis*	-	X	-
Histeridae	*Baeckmanniolus galidens*	-	-	X
	Carcinops sp.	-	X	-
	Saprinus lugens	-	X	-
Hydrophilidae	*Cercyon fimbriatus*	-	-	X
	Cercyon haemorrhoides	-	X	-
	Enochrus carinatus	-	-	X
Lathridiidae	*Akalyptoischion hormathos**	-	X	-
	*Cortilena casta**	-	X	-
	Corticaria sp.*	-	X	-
	*Melanophthalma americana**	-	-	X
Meloidae	*Meloe barbarus*	-	X	-
	Meloe strigulosus	-	-	X
Melyridae	*Amecocerus* sp*.	-	X	-
	*Endeodes insularis**	-	-	X
	Eutrichopleuris borealis	-	X	-
	Pristoscelis aenescens	-	X	-
	*Trichochrous calcaratus**	X	-	X
	Trichochrous sp.*	-	X	-
Mordellidae	*Mordellistena* sp.*	-	X	-
Nitidulidae	*Carpophilus ligneus*	X	-	-
	Undetermined sp.	X	X	-
Oedemeridae	Undetermined sp.	-	-	X
Rhizophagidae	*Phyconomus marinus*	-	-	X
Scarabaeidae	*Aphodius lividus*	-	-	X
	Bothynus californicus	-	-	X
	Bothynus scitulus	-	-	X
	Cyclocephala dimidiata	-	-	X
	Cyclocephala pasadenae	-	-	X
	Parathyce palpalis	-	X	-
	Phobetus sp.	-	X	-
	Polyphylla sp.		-	X
	Serica mixta	-	-	X
	Serica sp.	-	X	-
Scolytidae	*Pseudopityophthorus* sp.	-	X	-
Silphidae	*Heterosilpha ramosa*	-	-	X
	Nicrophorus nigrita	X	X	X
Staphylinidae	*Aleochara arenaria*	-	X	X
	Aleochara curtedens	-	X	-
	Aleochara sulicollis	-	-	X
	Bledius fenyesi	-	-	X

Appendix 2. Cont.

		Island		
	Species	**AI**	**SB**	**SM**
Staphylinidae	*Cafius canescens*	-	-	X
	Cafius lithocharinus	-	-	X
	Cafius luteipennis	-	-	X
	Cafius seminitens	-	-	X
	Hadrotes crassus	-	-	X
	*Staphylinus ater**	-	X	X
	Sunius sp.	-	X	-
	Tarphiota geniculata	-	-	X
	Tarphiota pallidoes	-	-	X
	Thinopinus pictus	-	-	X
	near *Oxypoda*	-	X	-
Tenebrionidae	*Apsena grossa*	-	X	-
	*Coelus globosus**	X	-	X
	*Coelus pacificus**	X	-	X
	*Coniontis lata**	X	X	X
	*Coniontis santarosae**	-	-	X
	Coniontis sp.*	X	-	-
	*Eleodes gigantea**	-	-	X
	*Eleodes inculta**	X	-	X
	*Eleodes laticollis apprima**	X	X	X
	Epantius obscurus	-	-	X
	Eusattus politus	-	-	X
	Helops bachei	-	X	-
	Helops sp.	X	X	-
Strepsiptera				
Halictophagidae	*Halictophagus insularum*	X	-	-
Trichoptera				
Undetermined	Undetermined sp.	-	-	X
Lepidoptera				
Arctiidae	*Apantesis nevadensis**	-	-	X
	Arachnis picta insularis	X	-	-
	Halysidota cf. *H. indistincta*	X	-	-
Danaidae	*Danaus plexippus*	X	X	-
Geometridae	*Eupithecia* sp.*	X	X	-
	*Merochlora faseolaria**	X	-	-
	Pergama macdunnoughi	X	-	-
	*Perizoma custodiata**	-	-	X
	*Perizoma epictata**	X	X	X
	Semiothisa californiaria	X	-	-
Hesperiidae	*Hylephila phyleus*	-	-	X
	Polites sabuleti	X	-	X
	Pyrgus communis albescens	X	-	-

	Species	Island		
		AI	SB	SM
Lycaenidae	*Brephidium exilis*	X	X	X
	*Everes amyntula**	X	-	X
	Leptotes marina	X	-	-
	Plebejus acmon acmon	X	-	-
	*Strymon melinus pudica**	X	X	X
Lymantriidae	*Orgyia vetusta*	X	X	-
Noctuidae	*Cucullia* ?	-	X	-
	*Euxoa riversii**	-	-	X
	Lacinipolia vicina or near*	-	X	-
	Lacinipolia sp. 1	X	-	-
	Lacinipolia sp. 2	X	X	-
	Melipotis sp.	-	X	-
	Orthosia praeses	-	X	-
	*Rhyncagrotis exertistigma**	-	X	-
	*Trichoclea edwardsii**	X	-	-
Nymphalidae	*Charidryas gabbii*	X	-	-
	Cynthia annabella	-	X	-
	*Cynthia cardui**	-	X	X
	Cynthia virginiensis	X	-	-
	Junonia coenia	X	-	-
Pieridae	*Colias eurytheme*	-	X	X
	Eurema nicippe	-	-	X
	Pieris protodice	-	X	-
Plutellidae	*Plutella xylostella**	-	X	-
Pterophoridae	*Platyptilia* sp.*	-	?	X
Pyralidae	*Dicymolomia metalliferalis**	X		-
	Euchromius prob. *ocellus**	-	X	-
	Ozamia sp.*	-	X	-
	Parargyractis sp.	-	X	-
	Udea berberalis	X	-	-
Pyromorphidae	Undetermined sp.	X	-	-
Sessiidae	*Melittia gloriosa*	-	X	-
	Undetermined sp.	X	-	-
Sphingidae	*Errinyis ello*	-	-	X
	Hyles lineata	X	X	-
Tortricidae	*Argyrotaenia franciscana insulana**	X	-	X
	*Argyrotaenia isolatissima**	-	X	-
	Clepsis peritana	-	X	-
Diptera				
Agromyzidae	*Phytomyza* sp.	-	X	-
Anthomyiidae	*Fannia* sp.*	X	-	-
	Phaonia sp.*	X	-	X
	*Scatophaga stercoraria**	X	-	X
	Scatophaga sp*.	X	-	-

		Island		
	Species	AI	SB	SM
Anthomyiidae	Undetermined sp.	X	-	X
Asilidae	*Dioctria pleuralis*	X	-	-
	Efferia anacapai	X	X	-
	Stenopogon neojubatus	-	X	X
Bombyliidae	*Bombylius lancifer**	-	-	X
	*Conophorus fenestratus**	-	-	X
	*Conophorus nigripennis**	-	-	X
	*Hemipenthes sinuosa iaennickeana**	X	-	-
	*Lepidanthrax hemologus**	-	X	-
	Parauilla n. sp.*	X	-	-
	*Ploas nigripennis**	-	-	X
Calliphoridae	*Paralucilia wheeleri**	X	-	-
	*Phaenicia sericata**	-	X	X
	*Phormia regina**	X	X	X
Ceratopogonidae	Undetermined sp.	X	-	-
Chloropidae	*Epichlorops* sp.	-	X	-
Coelopidae	*Coelopa vanduzeei**	X	-	-
Conopidae	*Thecophora* sp.	X	-	-
Culicidae	*Culicoides cacticolus*	X	-	-
	Culiseta inornata	X	-	-
Dolichopodidae	Undetermined sp.	X	-	X
Drosophilidae	*Drosophila pseudoobscura*	-	-	X
	Undetermined sp.	X		-
Empididae	*Rhamphomyia nigripennis**	-	-	X
Lonchaeidae	*Lonchaea* sp.*	X	X	X
Muscidae	*Tetramerinx sufitibia*	-	-	X
	Undetermined sp.	X	X	X
Sarcophagidae	*Sarcophaga* sp.*	-	-	X
	Undetermined sp.	X	X	X
Sepsidae	Undetermined sp.	-	X	-
Simuliidae	Undetermined sp.	X		-
Syrphidae	*Allograpta* sp.*	-	X	-
	Carposcalis sp.*	-	X	X
	*Eristalis latifrons**	X	-	X
	*Eristalis tenax**	X	-	-
	*Eupeodes volucris**	X	-	X
	Mesograpta sp.*	-	-	X
	Metasyrphus sp.*	X	X	X
	*Paragus tibialus**	-	-	X
	*Scaeva pyrastri**	X	-	X
	Sphaerophoria sp.*	-	X	-
	Volucella avida	-	-	X
	*Volucella mexicana**	X	-	X
	Volucella sp. 1*	X	-	-
	Volucella sp. 2*	X	-	X
Tabanidae	*Brennania hera*	-	-	X

Appendix 2. Cont.

		Species	Island AI	SB	SM
	Tabanidae	*Pilimas californica*	-	-	X
	Tachinidae	*Cylindromyia* sp.*	X	-	X
		Undetermined sp.	X	X	-
	Tephritidae	*Eutreta pacifica**	X	-	-
		*Paroxyna clathrata**	-	X	-
		Paroxyna sp.*	X	-	-
		*Tephritis araneosa**	-	X	-
		*Trupanea raditera**	-	X	-
		Trupanea sp.*	-	X	-
	Therevidae	*Thereva comata*	-	-	X
		Thereva sp.	-	X	-
	Tipulidae	*Limonia defuncta concinna**	-	-	X
		*Limonia marmorata**	X	-	X
Siphonaptera					
	Dolichopsyllidae	*Ceratophyllus pelecani*	-	X	-
		Opisodasys nesiotus	-	X	-
	Pulicidae	*Pulex irritans*	-	-	X
Hymenoptera					
	Andrenidae	*Andrena caerulea*	-	-	X
		Andrena perimelas	X	-	X
		Andrena prunorum prunorum	X	-	-
		Andrena sp. 3	-	-	X
		*Andrena submoesta**	-	-	X
		Perdita layiae layiae	-	-	X
	Anthophoridae	*Anthophora californica**	X	-	X
		*Anthophora edwardsii**	X	X	X
		*Anthophora urbana**	-	X	X
		Ceratina acantha	X	-	-
		Diadasia opuntiae	X	-	-
		Emphoropsis miserabilis	-	-	X
		Epeolus minimus	X	-	X
		Melecta separata	-	X	-
		*Melissodes lupina**	X	X	-
		Nomada edwardsii	-	-	X
		Nomada formula	X	-	X
		Nomada hesperia	-	X	-
		*Synhalonia edwardsii**	X	-	X
		*Synhalonia frater**	X	-	X
		Tetralonia atriventris	-	-	X
		Tetralonia cordleyi	-	-	X
		*Xeromelecta californica**	X	X	-
	Braconidae	*Apanteles* sp.	-	X	-
	Apidae	*Bombus californicus*	-	-	X
		Bombus crotchii	X	-	-
		Bombus edwardsii	X	-	-

Appendix 2. Cont.

	Species	Island AI	SB	SM
	Bombus nevadensis	-	-	X
	Bombus vosnesenskii	-	-	X
Colletidae	*Colletes hyalinus gaudialis**	X	-	X
Formicidae	*Aphaenogaster patruelis**	-	X	-
	*Crematogaster mormonium**	X	-	-
	Crematogaster sp.*	-	X	-
	Lasius niger	-	-	X
	*Monomorium minimum**	-	X	X
	*Tapinoma sessile**	-	-	X
	Veromessor sp.	-	X	-
Halictidae	*Agapostemon texanus**	X	X	X
	*Dialictus cabrilli**	-	-	X
	Dialictus diversopunctatum	-	X	-
	Dialictus grinnelli	-	-	X
	Dialictus megastictus	-	-	X
	Dialictus nevadense	-	X	X
	Dialictus perichlarus	X	X	X
	Dialictus pilosicaudus	-	-	X
	Dialictus punctiferellus	-	-	X
	Dialictus sp. 3	-	-	X
	Evylaeus hammondi	-	-	X
	Evylaeus miguelensis	-	-	X
	Lasioglossum pavonotum	-	-	X
	Lasioglossum sisymbrii	X	-	-
	Lasioglossum titusi	X	-	-
	Sphecodes nigricans miguelensi	-	-	X
Ichneumonidae	Undetermined sp. 1*	-	X	X
	Undetermined sp. 2*	-	X	X
Megachilidae	*Anthidium collectum*	-	X	-
	Anthidium maculosum	X	-	-
	Anthidium palliventre	-	-	X
	*Ashmeadiella californica californica**	X	X	-
	Osmia albolateralis	-	-	X
	Osmia nemoris	-	-	X
	Osmia nigrobarbata	-	-	X
	*Osmia trevoris**	-	-	X
Pompilidae	*Anoplius clystera**	-	-	X
	Undetermined sp. 1*	X	-	-
	Undetermined sp. 2*	-	X	-
Sphecidae	*Ammophila azteca azteca**	-	-	X
	*Bembix americana comata**	X	-	-
	*Bembix americana hamata**	-	-	X
	Diodontus occidentalis	-	-	X
	Miscophus californicus	-	-	X
	Oxybelus uniglumis quadrinota	-	-	X
	Palmodes insularis	X	-	X

Appendix 2. Cont.

	Species	Island AI	SB	SM
Sphecidae	*Podalonia compacta*	-	-	X
	Podalonia valida	-	-	X
	Prionyx canadensis	-	-	X
	Tachysphex clarconis	-	-	X
	Tachysphex tarsatus	-	-	X
Tenthredinidae	Undetermined sp.	X	-	-
Tiphiidae	*Brachycistis agama*	-	-	X
Vespidae	*Odynerus halophila*	-	-	X

Appendix 3. Taxonomists with an interest in Channel Islands invertebrates[1].

Dr. Julian Donahue
Entomology Department
Natural History Museum of Los Angeles County
900 Exposition Blvd.
Los Angeles, CA 90007
(Lepidoptera)

Dr. Ray Gill
Division of Plant Industry
California Department of Food and Agriculture
1220 N Street
Sacramento, CA 95814
(Homoptera except aphids)

Dr. Arnold S. Menke
c/o U. S. National Museum of Natural History
Washington, D. C. 20560
(Sphecid wasps)

Dr. Douglas R. Miller
Systematic Entomology Laboratory, IIBIII
Agricultural Research Service, USDA
BARC-West, Beltsville, MD 20705
(Mealybugs)

Dr. Scott E. Miller
Chairman, Dept. of Entomology
Bernice P. Bishop Museum
1525 Bernice Street, P.O. Box 19000A
Honolulu, HI 96817-0916
(island species of Hemiptera, Coleoptera and Lepidoptera)

Dr. Jerry A. Powell
Department of Entomological Sciences
University of California
Berkeley, CA 94720
(Microlepidoptera)

Dr. David B. Weissman
15431 Francis Oaks Way
Los Gatos, CA 95030
(Orthoptera)

[1]Taxonomic group of primary interest is noted in parentheses

Appendix 4. Equipment list and source of supplies. The numbers in parentheses indicate quantities when it is not obvious.

Field

- Pen with waterproof ink
- Clipboard
- Data forms
- Labels for labeling samples
- Aspirator for catching invertebrates
- Insect killing jars with plaster of Paris to hold ethyl acetate (6 - 8 in assorted sizes)
- Ethyl acetate for killing invertebrates
- Sweep net (2)
- Extra sweep net bags (4 - 6)
- Vacuum sampler with the smaller of the two funnels (D-Vac, model 1-A)
- Collecting bags for use with D-Vac (6 - 8)
- Gas can and oil for D-Vac
- Hearing protectors for use with D-Vac
- Malaise trap with collecting jar, stakes and guy lines (BioQuip, 3)
- Hammer for staking malaise trap
- UV light traps (BioQuip, 3)
- Gel cells - for light trap (9)
- Vials with 70% alcohol for collecting specimens (100 - 200)
- Spare cover boards (2 x 12 x 12 in.)
- Rubber bands for closing collecting bags
- Pack frame for carrying heavy or bulky supplies, e.g. light trap, malaise trap, vacuum sampler
- Calipers - high quality, small dial or digital
- Portable tape recorder for recording invertebrates under cover boards

Optional

- Walking stick or pole for locating boards
- Compass
- Portable computer for entering data at the field station

Laboratory

- Reference collection of invertebrates
- Gel cell recharger - 110 v and solar panel adaptor
- Dissecting scope for identification of invertebrates
- Ethyl alcohol (70%)
- Chlorocresol
- Fumigant for collections
- Freezer trays with lids (8 x 11 in.) - for sorting samples (6 - 8)
- Assortment of vials (1 - 8 dram) with stoppers (100 - 150)
- Insect boxes (12 - 15)
- Museum quality insect case

Insect Mounting Supplies

- Pinning boards (6 - 8)
- Labels
- Insect pins (sizes 00, 0, 1, 2, 3, 4) (100 ea.)
- Point punch and suitable card stock for points
- Shellac gel for mounting insects on points
- Pinning block
- Insect larvae forceps

Invertebrate Keys and References

- Arnett (1985)
- Borror et al. (1976)
- Borror and White (1970)
- Covell (1984)
- Hogue (1974)
- Martin (1977)
- Miller (1984a, 1984b)
- Rentz and Weissman (1982)
- Stephen et al. (1969)

Appendix 4. Cont.

General Invertebrate Collecting Supplies, Light Traps and Malaise Traps

Traps

BioQuip
P.O. Box 61
Santa Monica, CA 90406
213-324-0620

AMBI
1330 Dillon Heights Ave.
Baltimore, MD 21228
301-747-1797

Vacuum Sampler

D-Vac Co.
PO Box 95
Oakview, CA
(805) 643-5407

Appendix 5. Schedule of terrestrial invertebrate monitoring. The X's indicate which techniques are to be used each month. Unless otherwise noted, an X applies to all three islands. Hence in August, light trapping and sweep samples will be conducted on all three islands.

	Cover	Light	Malaise	Sweep	Vacuum
January	X[1, 2]	X	-	-	-
February	X[1, 2]	X	-	-	-
March	-	-	-	-	-
April	X[3, 4]	-	X	-	-
May	X[3, 4]	X	X	X	X
June	-	X	X	X	X
July	-	-	-	-	-
August	-	X	-	X	-
September	-	X	-	-	-
October	-	-	-	-	-
November	-	-	-	-	-
December	X[2]	X	-	-	-

[1]Samples are taken in January or February, but not both.
[2].Measure snails found under boards.
[3].Do not check cover boards on Santa Barbara Island in April and May. The negative impact on aestivating snails is likely to be greater than the information gained.
[4]Do not measure snails found under boards.

Appendix 6. Location of Board Transects and Sampling Locations.

EAST ANACAPA ISLAND

Cover Boards

Inspiration Point (INPO). This transect begins 8 m west of Nature Trail marker #7 (Midden) and runs in a direction of 266° true (roughly west). The second row of boards lies to the north of the first row. (Fig. 2a)

Lighthouse (LIGH). This transect runs at 72° true (roughly east) from the flagpole near the ranger residence. The first board is 15 m from the flagpole. The second row of boards lies to the north of the first row. (Fig. 2a)

Light Traps

Lighthouse Road (LIRO). This site is approximately 80 m E of the generator building on the gravel road which runs from the generator building to the lighthouse. The vegetation on either side of the road is *Coreopsis*. The light trap should be placed so that the light is visible for some distance on both the north and south sides of the road.

Midden (MIDD). Trail post 7 marks this site, which is on the southwestern part of the island on the trail leading to Inspiration Point. Scattered small shell fragments litter the trail at this point and the vegetation along either side is a *Coreopsis* association.

Campground *Coreopsis* (CACO). This site is 4 - 5 m east of the south end stake of plant transect 03 along the foot of the small hill slope that leads up to the south-facing bluff southeast of the campground. It is at the edge of *Coreopsis/Hemizonia* and grassland, and is best reached by cutting off of the trail between the helicopter landing pad and the campground. (Fig. 2b)

Malaise Traps

Fuel Tank Building (FTBU). The fuel tank building houses the large fuel tanks and has large solar panels on top. Set up the net in the *Coreopsis* southeast of the building. Look for an opening in the *Coreopsis* large enough to set the malaise trap.

South Bluff (SOBL). This transect is described above. Set the net along the edge between the *Coreopsis* and grass.

Visitor Center (VICE). This site is at plant transect 01, located northwest of the visitor center and south of the main trail. The ends of the transect are marked by angle aluminum posts. The vegetation is *Malephora crocea* and *Grindelia latifolia*. The net should be set up parallel to and about 3 m from the plant transect. (Fig. 2b)

Sweep Samples

Campground Grassland (CAGR). This site is at plant transect 02 which is just east (within 15 m) of the campground. The angle aluminum end stakes should be visible from the edge of the campground or along the trail leading up to the south bluff. Walk on either side of the plant transect (3 and 4 m away) while sweeping. Do not trample the transect itself. (Fig. 2b)

Visitor Center (VICE). This transect is described above. Walk parallel to the transect (3 and 4 m away) while sweeping. Do not trample the transect itself.

Vacuum Samples

Campground *Coreopsis* (CACO). This transect is described above. Though the transect runs partially through grassland, the vacuum sample will include only the *Coreopsis*.

Campground Grassland (CAGR). This transect is described above. The vacuum sample will include both grasses and the low shrub, *Hemizonia clementina.*

SW Sagebrush (SWSA). Follow the Nature Trail to Inspiration Point, then take the trail (north) which leads to the gull colony. Relatively dense *Artemisia californica* bounds the trail on either side through this stretch. Get off the trail to the east and sample several of these shrubs.

MIDDLE ANACAPA ISLAND

Cover Boards

Central Grassland (CEGR). This transect is on the main terrace. It runs along the trail from the eucalyptus grove (Sheep Camp). The first board is near the angle aluminum end marker for plant transect 05. While the spacing between boards is approximately 5 m, the transect is not straight. The vegetation is low, however, so boards are generally easy to locate. Note that the transect consists of only 30 boards. (Fig. 2a and 2c).

Fish Camp Sagebrush (FCSA). This transect is located in an area of *Artemisia californica* and grassland on the bluff overlooking East Fish Camp. The first board is near plant transect 01. The boards run approximately north, ending on the north-facing bluff overlooking the Santa Barbara Channel, at the west end of "knife edge." While the spacing is approximately 5 m between boards, the transect is not straight. The vegetation is low along the middle part of this transect, so boards along that stretch are easy to locate. The beginning and ending boards can be located by reference to these middle boards, if necessary. Note that the transect consists of only 30 boards and is called "Sagebrush" in the Terrestrial Vertebrate Handbook. (Fig. 2a and 2d)

Light Traps

Central Stipa Grassland (CSGR). This site is at plant transect 05, a *Stipa* grassland southwest of the trail leading from the eucalyptus grove (Sheep Camp) toward the southeast end of the island. The light trap is set along the trail in the *Stipa/Dudleya* grassland close to the end stake of plant transect 05. (Fig. 2c)

Eucalyptus Grove (EUGR). This site is near the large eucalyptus trees (Sheep Camp). Set the light trap along the trail just below the grove of trees so that you are sampling a combination of seabluff shrubs and the large grass, *Elymus condensatus.*

Malaise Traps

Central *Stipa* Grassland (CSGR). This transect is described above. The malaise trap should be set parallel to the transect, with the low end toward the west.

North Terrace (NOTE). This site is at plant transect 03 which is not along any of the mapped trails. It can be reached by skirting the gullies on the main terrace east of the eucalyptus grove (Sheep Camp) and then along the north edge of the main terrace. Look for the angle aluminum stakes which mark the ends of the transect. The transect is oriented north-south and the malaise net will be set up perpendicular to the transect, with the low end to the west. The vegetation is a combination of *Stipa pulchra, Dudleya caespitosa* and annual grasses. (Fig. 2c)

Sweep Samples

Central *Stipa* Grassland (CSGR). This site is described above. You will sample a mixture of perennial and annual grasses along this transect.

North Terrace (NOTE). This site is described above. You will sample a combination of grasses and shrubs.

Vacuum Samples

None

WEST ANACAPA

Cover Boards

West Terrace (WETE). This transect runs to the east along the southern edge of a deer mouse grid. Board 1 is at mouse stake 10,1 and is approximately south of the seismograph antenna. The second row of boards lies to the south of the first. (Fig. 2a)

Light Traps

Campsite (CAMP). This site is at the west end of the 100 m terrace at the west end of the island, just east of the top of the rocky ridge leading up from Rat Rock. It has traditionally been used as a campsite by researchers. Place the light trap among the *Coreopsis* and *Baccharis*. Aim for a balance between a protected site (if it is windy) and one that allows the light to be seen for some distance away.

Oak Canyon (OACA). This site is on the west side of the canyon, across from plant transect 02. The best way to reach this site is to follow the top of the north-facing bluff, where the shrubby vegetation is not so dense. Angle to the southeast as you approach the mouth of Oak Canyon. This will take you through some dense shrubs. Look for a relatively open area on the upper east-facing slope of the canyon, north of the lower fork. The vegetation is annual grasses with *Artemisia californica* and cherry trees nearby. Be careful to avoid the poison oak growing in the canyon here. (Fig. 2e)

Seismograph (SEIS). This site is at plant transect 06 which is at the east end of the west terrace, east of the seismograph antenna and just north of the trail leading up to Summit Peak. The transect is in open grassland and the angle aluminum end stakes are easily seen. Place the light trap near the east end stake. (Note that the orientation of the transect as shown in the Vegetation Monitoring Handbook is incorrect. The transect stakes are oriented approximately east - west.) (Fig. 2f)

Summit Peak (SUPE). This site is at plant transect 01 which is east of the small knoll east of Summit Peak. The end stakes are 10 - 15 m downslope (north) of the trail and are easily visible from the trail. Place the light trap near one of the end stakes but 2 - 3 m away (above or below) from the transect itself. (Note that the Vegetation Monitoring Handbook maps the transect correctly, but the narrative "Transect Location" mistakenly states that the transect is south of the trail). The vegetation includes a variety of endemic shrubs. (Fig. 2g)

Malaise Traps

Oak Canyon (OACA). This transect is described above.

Seismograph (SEIS). This transect is described above. The malaise trap should be set up parallel to the transect (east - west) with the low end toward the west.

Summit Peak (SUPE). This transect is described above. The malaise trap should be set parallel to the transect (east - west) with the low end toward the west.

Sweep Samples

Oak Canyon (OACA). This transect is described above, but note that the sweep sample is taken on the east side of the canyon. The other samples are on the west side. You will be sweeping shrubs at this site.

Seismograph (SEIS). This transect is described above. You will be sweeping grassland at this site.

Summit Peak (SUPE). This transect is described above. You will be sweeping a variety of shrubs at this site.

Vacuum Samples

None

SANTA BARBARA ISLAND

Cover Boards

Cave-Middle Canyon (CMCA). Three parallel rows of 20 boards each are located on the terrace between Cave and Middle Canyons. The rows are spaced approximately 10 m apart and run toward the east at approximately 90° true. Spacing between boards is approximately 5 m. Board 1 is at the west end of the southern row, approximately 250 m east of the Saddle Trail, starting from the vicinity of the bridge. Board 60 is at the east end of the northern row. (Fig. 3a)

Middle Canyon (MICA). This transect is located in the upper part of Middle Canyon. It begins at the head of the canyon about 10 m west of the first *Coreopsis* farthest up the canyon and extends toward the mouth of the canyon. The first board is at the foot of the north-facing slope of the canyon, across from a small stand of *Artemisia californica* on the opposite slope. The boards continue down the canyon along the base of the north-facing slope. The parallel transect runs along the south-facing slope. (Fig. 3a)

Middle-Graveyard Canyon (MGCA). This transect runs between Middle and Graveyard Canyons. Board 1 is near the top of the old trail that crosses lower Middle Canyon. From there the transect continues toward Graveyard Canyon and the southeast slope at about 100° true. The parallel transect lies to the east. (Fig. 3a)

Terrace *Coreopsis* (TECO). This site is located in the western part of the *Coreopsis* stand northwest of the Badlands, along the west side of the deer mouse grid. From the "Y" in the Saddle Trail, walk about 525 m south (towards the Badlands). Then turn right (west) and walk about 80 m out into the *Coreopsis* being careful not to trample small *Coreopsis*. The arrangement of boards here differs from the standard arrangement in having three rows of eight boards each. The rows are oriented approximately north - south and spacing between boards is 3.5 m, both within and between rows. The numbering goes across the rows, starting at 701 at the northeast corner then winding back and forth, first to the west, then to the east and so forth. The last three boards, at the south end, are 722 (southwest), 723 (middle) and 724 (southeast). (Fig. 3a)

Terrace Grassland (TEGR). This transect is located in the grassland area between the upper Saddle Trail and the Badlands *Coreopsis* stand. The first board is reached from the "Y". Proceed 320 m to the south (toward the Badlands) and then 80 m west into the grassland. The second row of board lies to the west of the 1 - 30 row. Spacing between boards is approximately 5 m. (Fig. 3a)

Webster Point (WEPO). This transect runs in a westerly direction across the upper west terrace. Walk down the trail from the saddle onto the terrace, where the trail runs along the top of the west-facing cliffs. Proceed along the trail about 140 m beyond the north edge of the old cistern - a large (100 m+ diameter) semicircular bare area along the east side of the trail. Then get off of the trail and walk in a direction just west of North Peak. Continue in this direction about 150 m through the *Mesembryanthemum* and *Suaeda*. This will bring you to the center of the first row of boards. Board 1 lies to the east. The second, parallel row is to the north. (Fig. 3a)

Light Traps

Cave Canyon (CACA). This site is in the bottom of Cave Canyon along plant transect 9. Look for post 4 of the Nature Trail and a dark, rounded, outcropping rock along the rim of the canyon, upslope of the transect. Carefully pick your way down the slope to the bottom of the canyon. Watch out for cactus and take care not to dislodge rocks, compact the soil or leave a trail that will tempt visitors to follow your course. The end stakes of the vegetation transect are not easy to see when the vegetation is thick. Find a spot in the bottom of the canyon which is not crowded by *Coreopsis* and other shrubs to set the light trap. (fig. 3b).

Landing Cove (LACO). This site is at the switchback in thetrail halfway up the Landing Cove from the dock. Set the light trap on top of the bench. You will be sampling a combination of *Coreopsis, Hemizonia clementina, Suaeda californicum* and grasses.

Nature Trail (NATR). This site is on the sea slope N of Cave Canyon. Place the light trap 5 - 10 m downslope (east) of the east side of the Nature Trail, about 70 m north of the southeast corner of the trail loop. This location is on a fairly steep, rocky sea slope, just south of a low outcropping rock wall and associated swale which drains down the sea slope. Several prickly pear clumps are in this swale while the area immediately surrounding the trap is grass and *Eriogonum*. You will have to position the trap carefully so that it is stable on the steep slope.

NE Grassland (NEGR). This site is adjacent to plant transect 18. To reach the site, walk about 100 m up the trail from the Ranger Station toward the saddle. The angle aluminum end stakes marking the transect should be visible in the grassland to your right. Place the light trap up slope of the south end stake. (Fig. 3b)

West Terrace (WETE). This site is at plant transect 03 which is at the southeast corner of the upper west terrace, north of the broad curve the trail makes after it descends from the saddle. The transect is about 75 m north of this curve in the trail. Place the light a few m east of the south end stake. The vegetation is this area is *Mesembryanthemum crystallinum* and *Suaeda californica*. (Fig. 3c)

Malaise Traps

Cave Canyon (CACA). This transect is described above. Find a relatively clear area near plant transect 09 and set the trap in the bottom of the canyon, perpendicular to the course of the canyon (north - south).

NE Grassland (NEGR). This transect is described above. Set the trap on the downslope side of the plant transect, oriented west - east. Do not set the trap so that it is across the transect and try to avoid walking along the line between the two end stakes.

West Terrace (WETE). This transect is described above. Set the trap on the on the east side of the transect, oriented west - east.

Sweep Samples

NE Grassland (NEGR). This transect is described above. Walk parallel to the transect (3 - 4 m away) while sweeping. Do not trample the transect itself.

Elephant Seal Cove (ESCO). This site is at plant transect 02, south of the bridge along the trail southwest of Elephant Seal Cove. The transect is just east of the gully which the bridge spans and, like the gully, the transect is oriented approximately north-south. From the bridge, follow the gully 35 m south to the north end stake. The vegetation along this transect varies considerably from year to year. During some sampling periods you will be sweeping dense *Suaeda* and other periods you will be sampling sparse *Suaeda* and *Mesembryanthemum*. (Fig. 3d)

Vacuum Samples

Cave-Middle *Coreopsis* (CMCO). This sample is taken from *Coreopsis* on the terrace south of upper Cave Canyon. The exact location is not critical here. Simply branch off from the Saddle Trail around the head of Cave Canyon and select an area just south of the rim of the canyon with several large *Coreopsis* in close proximity.

Landing Cove *Eriogonum* (LCERG). From the trail at the top of the Landing Cove, walk (off the trail) partway down the broad shoulder of the canyon in the direction of the dock. This will bring you near a number of large *Eriogonum* and *Eriophyllum*. Sample the *Eriogonum*.

Landing Cove *Eriophyllum* (LCERP). This site is the same as described for Landing Cove *Eriogonum* above. Sample the *Eriophyllum*. Be particularly careful as the branches are very brittle.

North Peak (NOPE). Follow the trail from the Ranger Station up to the saddle and then to North Peak. Just before you reach the large *Coreopsis* stand on the east slope of North Peak (downslope from the trail) get off the trail and make your way downslope toward the east. Step carefully and pick your path to avoid making a trail that visitors will see. Proceed about 75 m down slope and sample the *Hemizonia clementina* shrubs scattered through the grassland east and southeast of this point.

Signal Peak (SIPE). Go to the top of Signal Peak via the saddle. Take the right angle turn at the south edge of the peak and follow the trail east to where it curves around and starts to go down toward Cat Canyon (about 80 - 100 m from the turn in the trail). Sample the scattered *Artemisia californica* north of the trail at this point.

SAN MIGUEL ISLAND

Cover Boards

Air Strip (AIST). Follow the administrative trail east from the Ranch House airstrip (toward Cardwell Point) for a distance of about 425 m. (The trail leads off to the south-southeast from a lone *Coreopsis* about 50 m west of the east end of the airstrip.) This transect is within the Willow Canyon fox grid. The transect starts just south of the trail and board 1 is adjacent to fox grid stake 36. From here the transect extends in an easterly direction (95° true). The parallel row of boards (31 - 60) lies to the south of the 1 - 30 row. (Fig. 4a)

Nidever Canyon *Lupine* (NCLU). This transect is located within the San Miguel Hill fox grid. Board 1 is 32 m at 89° from fox grid stake 3. The transect runs to the east toward the antenna of the seismic station. The parallel row of boards lies to the north. Many of the boards in this transect are inconspicuous because of the dense vegetation. (Fig. 4a)

San Miguel Hill (SMHI). This transect is located within the San Miguel Hill fox grid. Board 1 is adjacent to fox grid stake 13. The transect runs to the west with a compass heading of 269°. The parallel row of boards lies to the north. The layout of this transect is conspicuous because of the low vegetation. (Fig. 4a)

West Green Mountain (WGMO). This transect is located within the Green Mountain fox grid. Board 1 is adjacent to fox grid stake 88. The transect runs to the west with a compass heading of 270°. The parallel transect lies to the north. (Fig. 4b)

Willow Grassland (WIGR). This transect is located within the Willow Canyon fox grid. Board 1 is adjacent to fox grid stake 38. The transect runs to the west with a compass heading of 269° from true north. The parallel transect lies to the north. (Fig. 4a)

Light Traps

Cabrillo Monument (CAMO). This site is at plant transect 08. To get there, begin at the Cabrillo Monument, then strike off through the grass and shrubs toward the grassy knoll east of the monument. The transect is about 150 m NE of this knoll in an area of *Lupinus arboreus* and *Astragalus miguelensis*. (From the site of the plant transect, the wind sock at the airstrip is 206° true and it is 330° true to Harris Point.) Note that this area is very exposed. It may be difficult to find times when the weather is suitable to sample here. (Fig. 4c)

Central Willow Canyon (CWCA). Start at the head of Willow Canyon and follow along the bottom until you reach an area where the canyon consists of outcropping sandstone and boulders and there is a dense cover of *Artemisia californica* on the slopes (250 m down-canyon from this area is a large sandstone waterfall). Place the light in the canyon bottom adjacent to the *Artemisia*.

East End Dunes - N (EEDN). This site is at plant transect 13 which is south of the west end of the large dunes which make up the "wind tunnel" which extends from the east end of Cuyler Harbor toward lower Willow Canyon. To reach the site, start at the beach at the east end of Cuyler Harbor, at the base of the large shell-midden. Skirt this midden and walk 300 m up the dunes from the beach, staying along the S edge of the dune strip. From this point, turn due S and walk about 70 m. Plant transect 13 begins at a small patch of stunted *Coreopsis* and extends in an easterly direction, paralleling the dune field. It is easy to spot because of the low vegetation. The vegetation is predominantly *Malacothrix incana*, *Bromus diandrus* and *Calystegia macrostegia*. Note that this area is very exposed. It may be difficult finding times when the weather is suitable to sample here. (Fig. 4d)

East End Dunes - S (EEDS). This site is at plant transect 12. To get there, follow the directions for East End Dunes - N (above), but continue 100 m south to plant transect 12. (From transect 12, the west end of Prince Island is about 346° true. Hare Rock is ca. 312°; Bay Point is 86°; and Hoffman Point is 66°.) The vegetation is predominantly *Lupinus albifrons, Calystegia macrostegia* and *Carpobrotus aequilaterus*. Note that this area is very exposed; it may be difficult finding times when the weather is suitable to sample here. (Fig. 4d)

Lower Willow Canyon (LWCA). This site is at plant transect 16. It can be reached either by following the bottom of Willow Canyon or by walking cross-country toward the lower canyon. After the big bend in the canyon, where it turns from its easterly flow to a northward course, get up onto the terrace east of the canyon. Follow along the rim of the canyon toward the ocean to a low ridge which extends southeast from the canyon. Plant transect 16 is near the foot of this ridge, about 40 m from the canyon rim (south of the ridge and east of the canyon). The predominant vegetation is *Haplopappus venetus* and *Astragalus miguelensis*. (Fig. 4e)

Nidever Canyon Gully 1 (NCG1). This site is in the lower part of the gully system west of upper Nidever Canyon with dense *Baccharis*. From the Ranger Station, follow the administrative trail to the northwest until you reach the board bridge at the first gully. Place the light either on the bridge or on the trail to either side. Do not place the trap such that branches of the surrounding *Baccharis* are actually touching or blocking the light trap.

Nidever Canyon Lupine (NCLU). This area is in a stand of *Lupinus albifrons* with *Baccharis* mixed in. Take the trail which leads up to the helicopter pad then continues south toward San Miguel Hill. Follow this trail until you reach the heads of the gullies which cut across the flat to the west. Turn off the trail to the west and walk toward the area of dense lupine. Place the light so that it has lupine bushes on all sides but is not crowded by them. Note that this area is very exposed. It may be difficult finding times when the weather is suitable to sample here.

Upper Nidever Canyon (UNCA). Place the light in the bottom of upper Nidever Canyon, 60 m S of the Ranger Station. The surrounding vegetation on the canyon slopes here is *Baccharis* and other shrubs.

Willow Canyon Mouth (WCMO). This site is at plant transect 15 which is on the beach terrace southeast of the mouth of Willow Canyon. The general area can be reached either by following the bottom of Willow Canyon or by walking cross-country toward the canyon mouth. Once near the mouth, get up on the low terrace on the east side of the canyon. Plant transect 15 is on this terrace, between the canyon mouth and a low dividing ridge which runs southeast from the canyon. Place the light in the *Coreopsis* and *Hordeum*. Note that there are two plant transects along the east side of lower Willow Canyon. This is the one which is farther north, within sight of the canyon mouth. Also note that this area is very exposed and hence it may be difficult finding times when the weather is suitable to sample here. (Fig. 4f)

Malaise Traps

Cabrillo Monument (CAMO). This transect is described above. Place the malaise trap a few m off the line of the transect with the long axis of the trap along the direction of the prevailing wind. Note that this area is very exposed. It may be difficult finding times when the weather is suitable to sample here.

East Cabrillo Annual Grassland (ECAG). This site is also east of Cabrillo Monument/Nidever Canyon area. From the turn in the trail which leads to the airstrip, walk about 525 m east. This will bring you to a point south of the head of Willow Canyon, along an old fence line. Set the trap in the annual grassland with its long axis in the direction of the prevailing wind.

East Cabrillo Native Grassland (ECNG). This is a small patch of *Stipa* east of the Cabrillo Monument/Nidever Canyon area in the same direction as the annual grassland described above. From the point where the trail from Nidever Canyon and the monument turns south to go to the airstrip, get off the trail and walk about 330 m east, staying on the south side of the old fence line. Place the malaise trap in the center of the area of *Stipa*.

East End Dunes - N (EEDN). This transect is described above. The trap should generally be set up with the long axis parallel to the long axis of the dune fields. Note that this area is very exposed. It may be difficult finding times when the weather is suitable to sample here.

East End Dunes - S (EEDS). This transect is described above. The trap should generally be set up with the long axis parallel to the long axis of the dune fields. Note that this area is very exposed. It may be difficult finding times when the weather is suitable to sample here.

Lower Willow Canyon (LWCA). This transect is described above. As with the other sites, set up the trap with its long axis along the direction of the prevailing wind.

Nidever Canyon Lupine (NCLU). This transect is described above. Place the malaise trap so that its axis is along the direction of the prevailing wind. Note that this area is very exposed. It may be difficult finding times when the weather is suitable to sample here

Upper Nidever Canyon (UNCA). This transect is described above. Place the malaise trap perpendicular to the course of the canyon.

Willow Canyon Mouth (WCMO). This transect is described above. Set up the trap with its long axis along the direction of the prevailing wind. Note that this area is very exposed. It may be difficult finding times when the weather is suitable to sample here.

Sweep Samples

Cabrillo Monument (CAMO). This transect is described above. Walk on either side of the plant transect (3 - 4 m away) while sweeping. Do not trample the transect itself.

East Cabrillo Native Grassland (ECNG). This transect is described above.

Lower Willow Canyon (LWCA). This transect is described above. Walk on either side of the plant transect (3 - 4 m away) while sweeping. Do not trample the transect itself.

SE Terrace (SETE). Follow the administrative trail which leads from the airfield east toward Cardwell Point until you are south of the west end of the dune fields between Willow Canyon and Hoffmann/Bay Point. Turn south to the top of the south bluff and proceed to a low knoll bearing the benchmark "Knox." Plant transect 10 is about 150 north of this benchmark in the annual grassland. Sample the annual grasses along the transect. (Fig. 4g)

SW Green Mountain (SWGM). This site is at plant transect 04, southwest of Green Mountain. Follow the cross-island trail west over the south end of Green Mountain. When you get down the mountain and back onto the flat, turn off the trail to the south. There is a drainage south of this point (west of South Green Mountain Canyon). Walk toward the drainage aiming for a point between the two large forks. Plant transect 4 is in grassland between the upper reaches of these two forks. Look for the aluminum end stakes. If you go too far you will reach transect 5 which is at the bluff edge. Sample the *Stipa pulchra* and *Avena barbata*. (Fig. 4h)

Vacuum Samples

Nidever Canyon *Coreopsis* (NCCO). Take the main trail from the Ranger Station north and turn on to the trail which leads toward the Cabrillo Monument and the airstrip. Sample the large *Coreopsis* on the south side of the trail immediately after you turn.

Harris Point *Astragalus* (HPAS). This site is located in the Harris Point fox grid. Follow the administrative trail northwest from the Ranger Station toward Harris Point. The trail crosses two gullies and then passes near the bluff overlooking Cuyler Harbor. Continue west to where the trail joins the old Harris Point ranch road. Cross the road and continue cross-country to fox stake 69. Sample the *Astragalus miguelensis* in the vicinity of this stake. (Fig. 4i)

Harris Point *Malacothrix* (HPMA). This site is the same as the "Harris Point *Astragalus*" described above. Sample the *Malacothrix incana* in the vicinity of fox stake 69.

Nidever Canyon Gully 2 (NCG2). Follow the administrative trail northwest from the Ranger Station to the second gully. There is a board bridge across both gullies. Sample the *Baccharis* in the vicinity of the second board bridge.

Figure 2a. Location of invertebrate sampling sites on Anacapa Island.

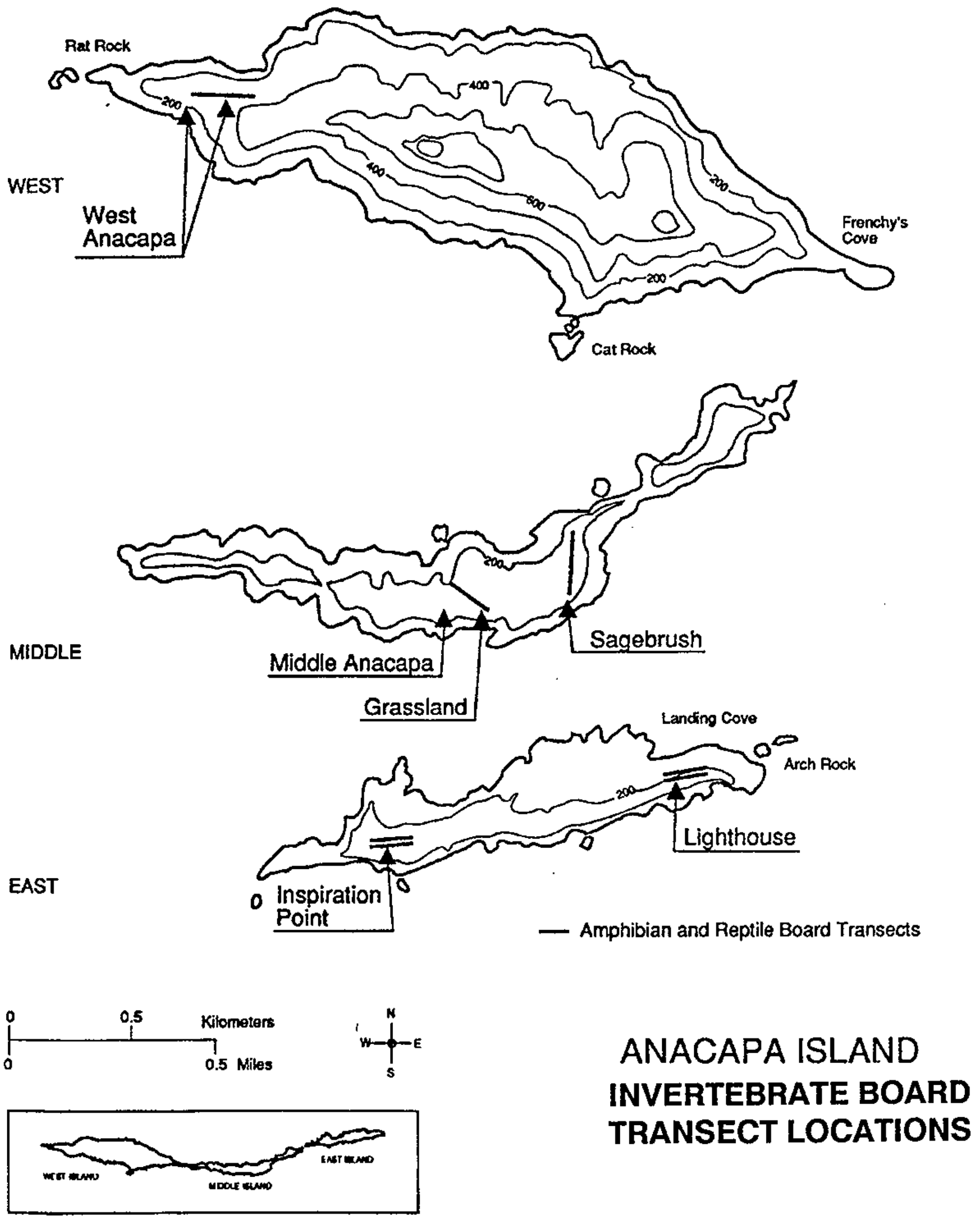


Figure 2b. Location of invertebrate sampling sites on East Anacapa Island.

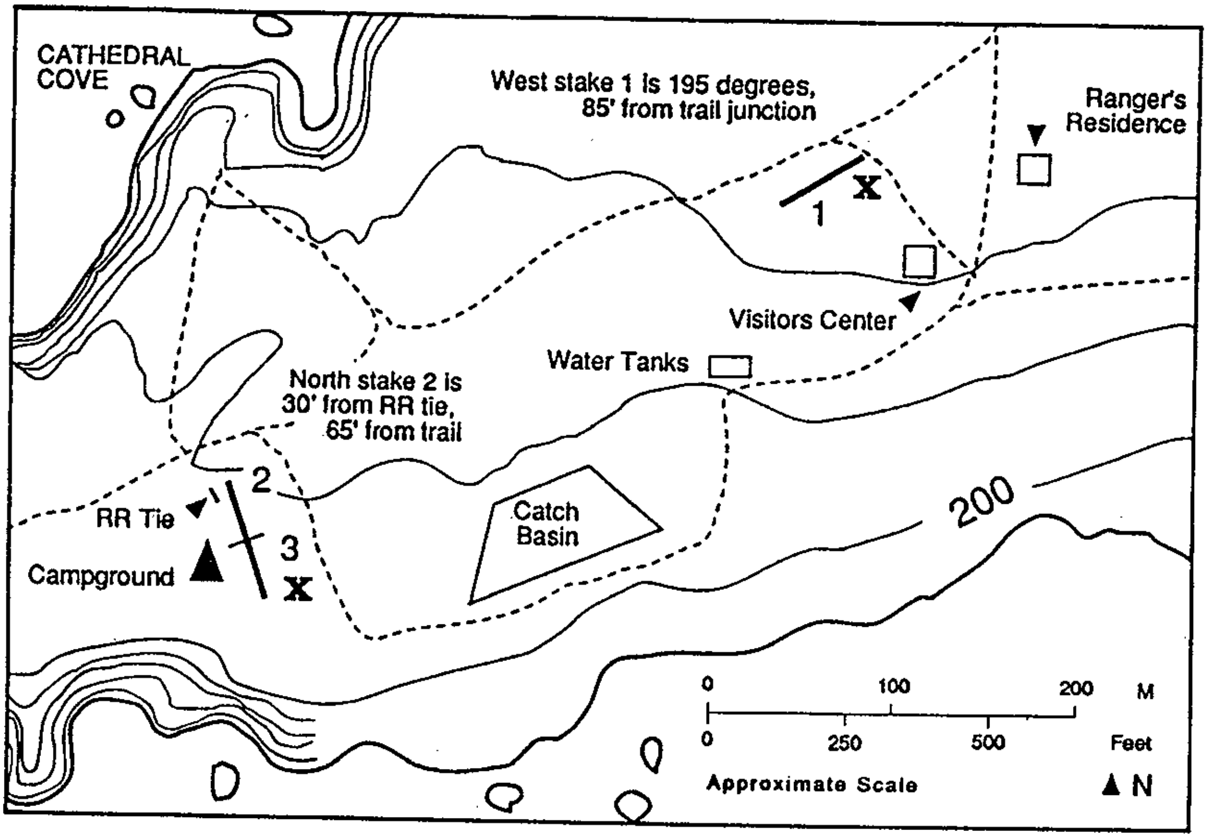


Figure 2c. Location of invertebrate sampling sites on Middle Anacapa Island.

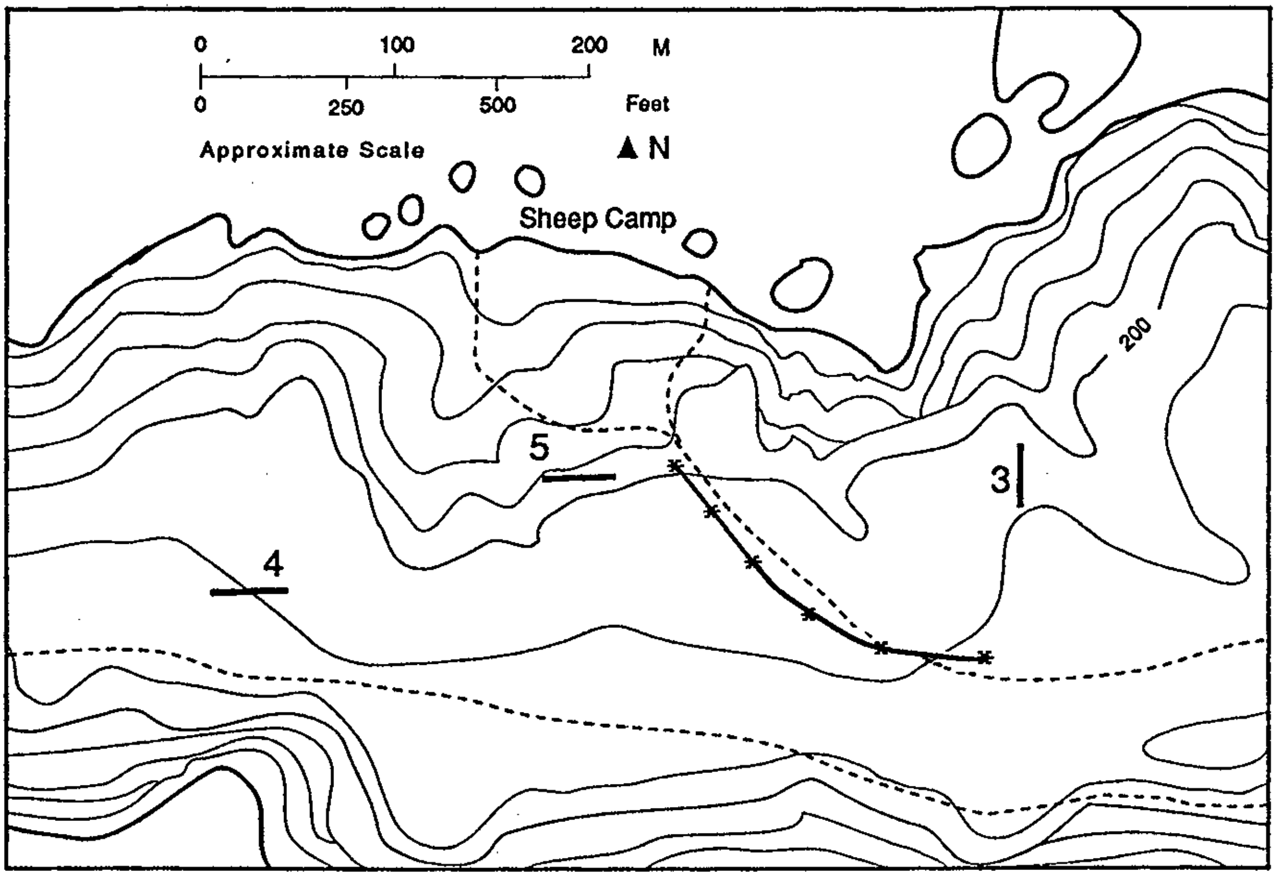


Figure 2d. Location of invertebrate sampling sites on Middle Anacapa Island.

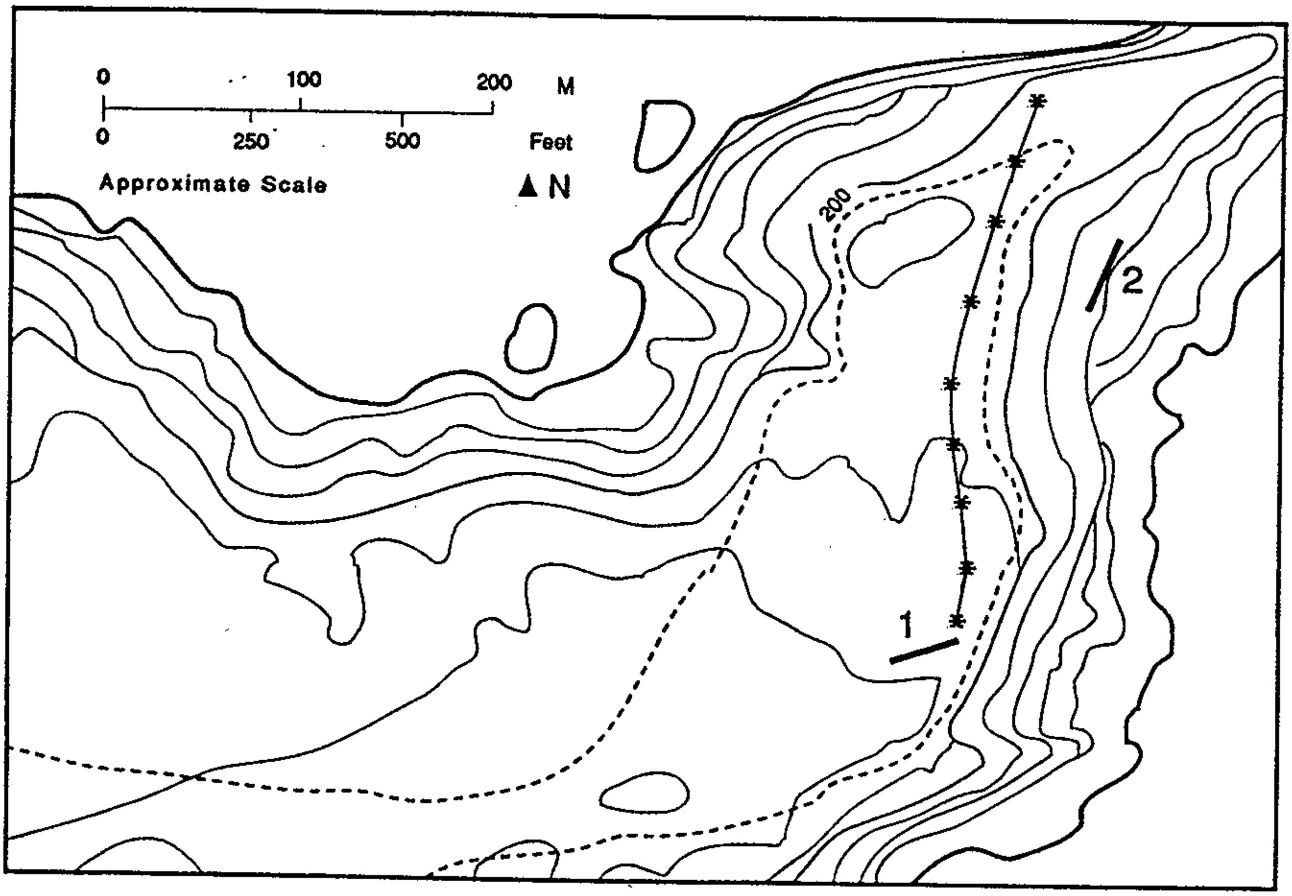


Figure 2e. Location of invertebrate sampling sites on West Anacapa Island

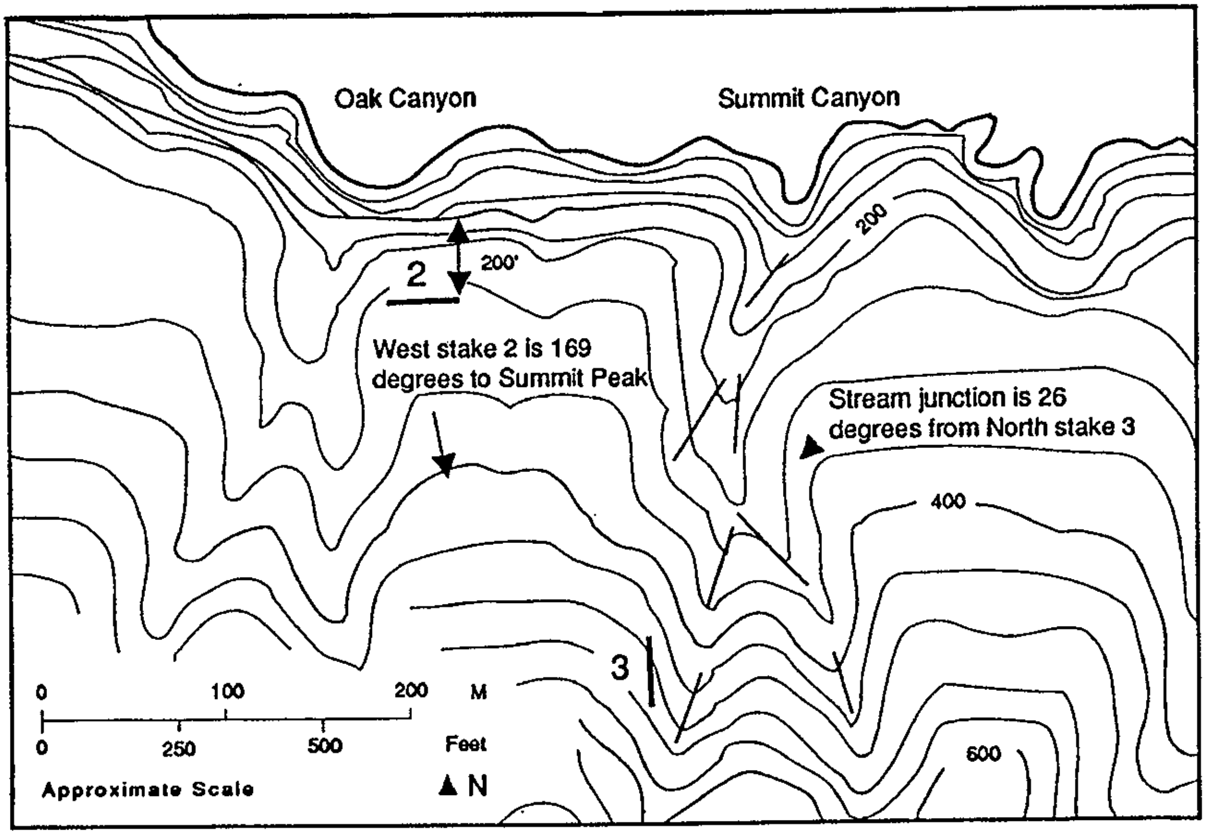


Figure 2f. Location of invertebrate sampling sites on West Anacapa Island

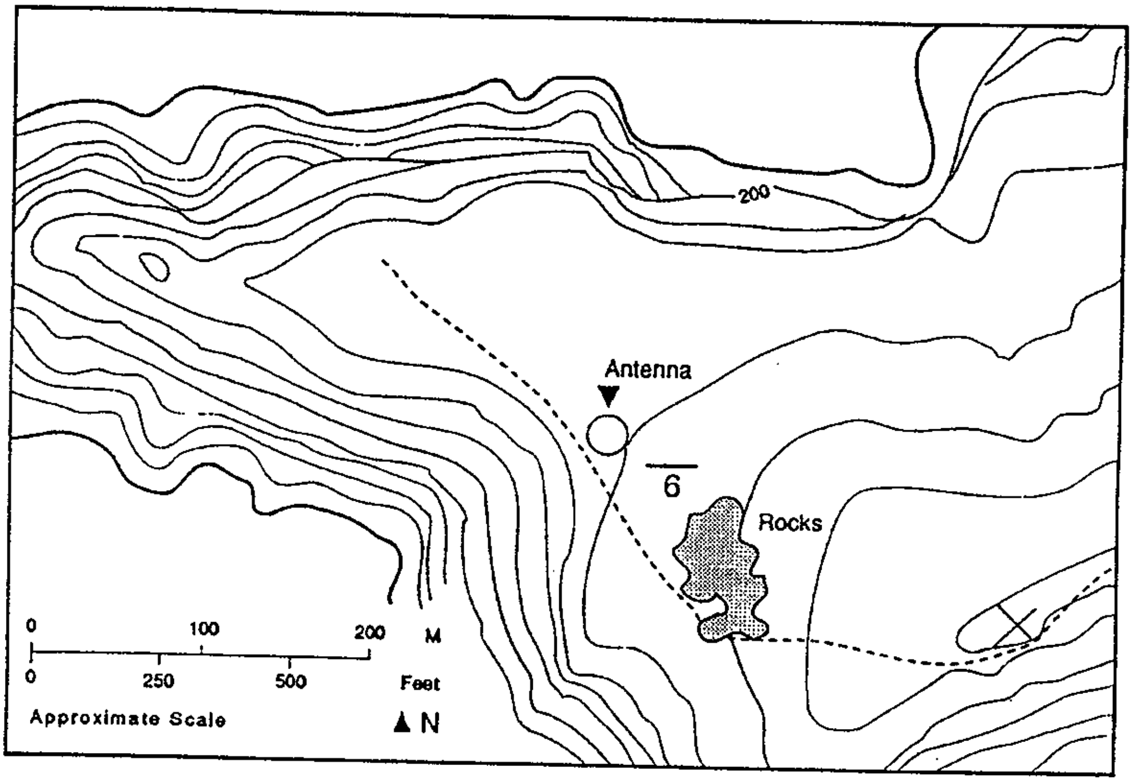


Figure 2g. Location of invertebrate sampling sites on West Anacapa Island

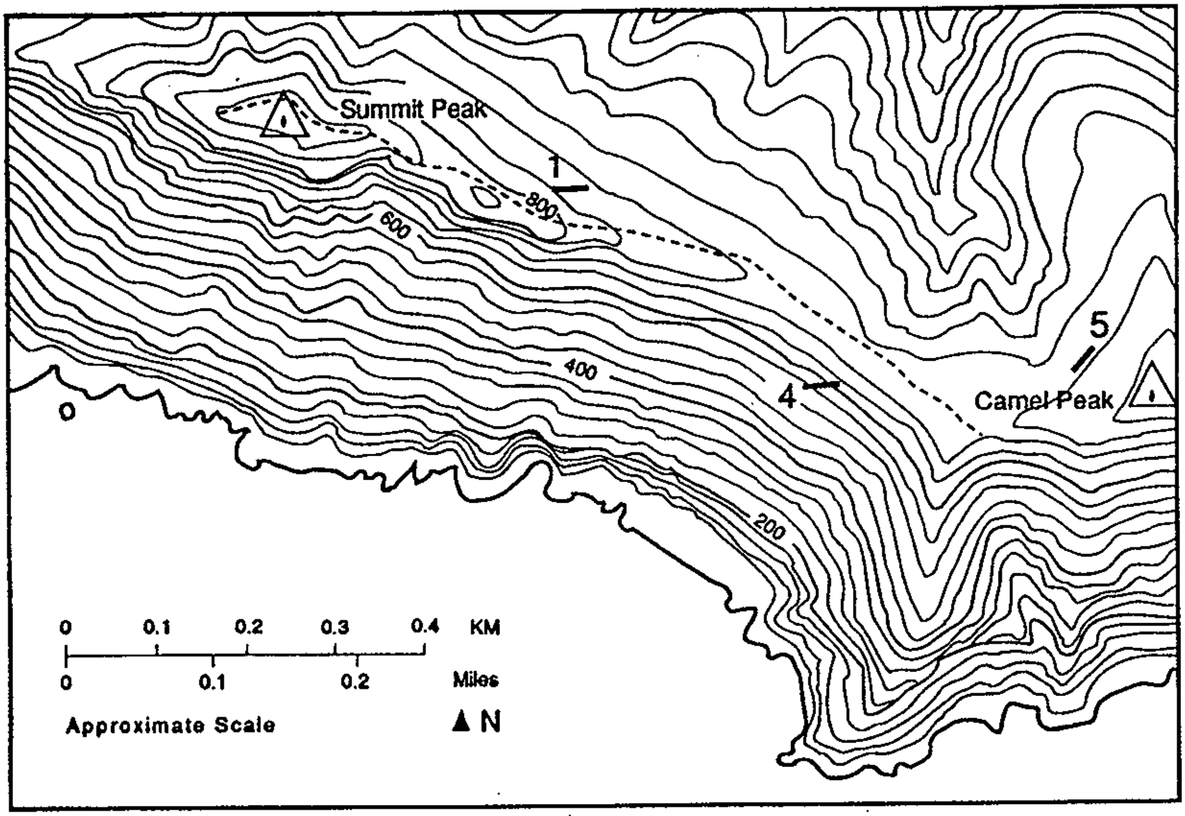


Figure 3a. Location of invertebrate sampling sites on Santa Barbara Island

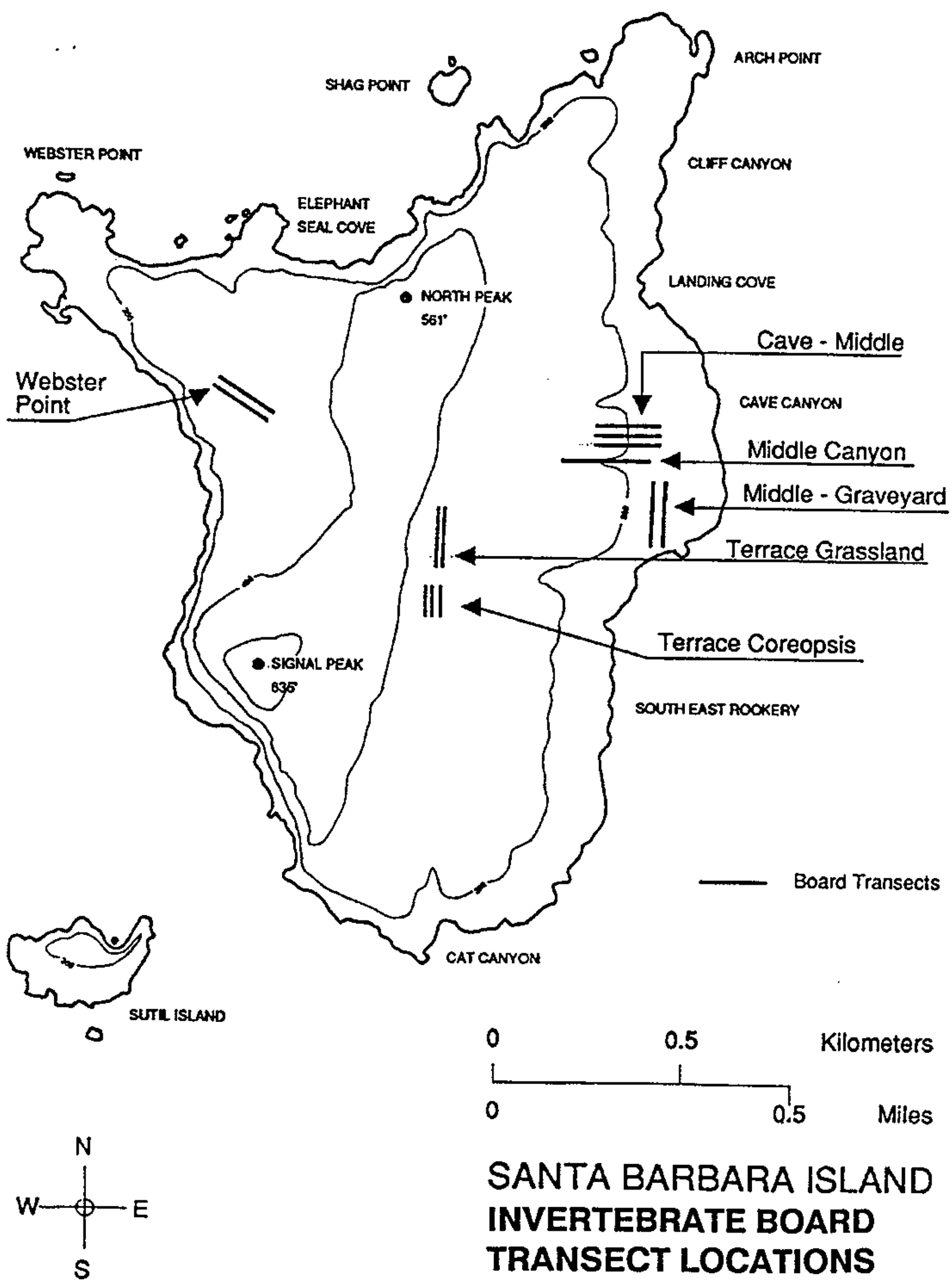


Figure 3b. Location of invertebrate sampling sites on Santa Barbara Island.

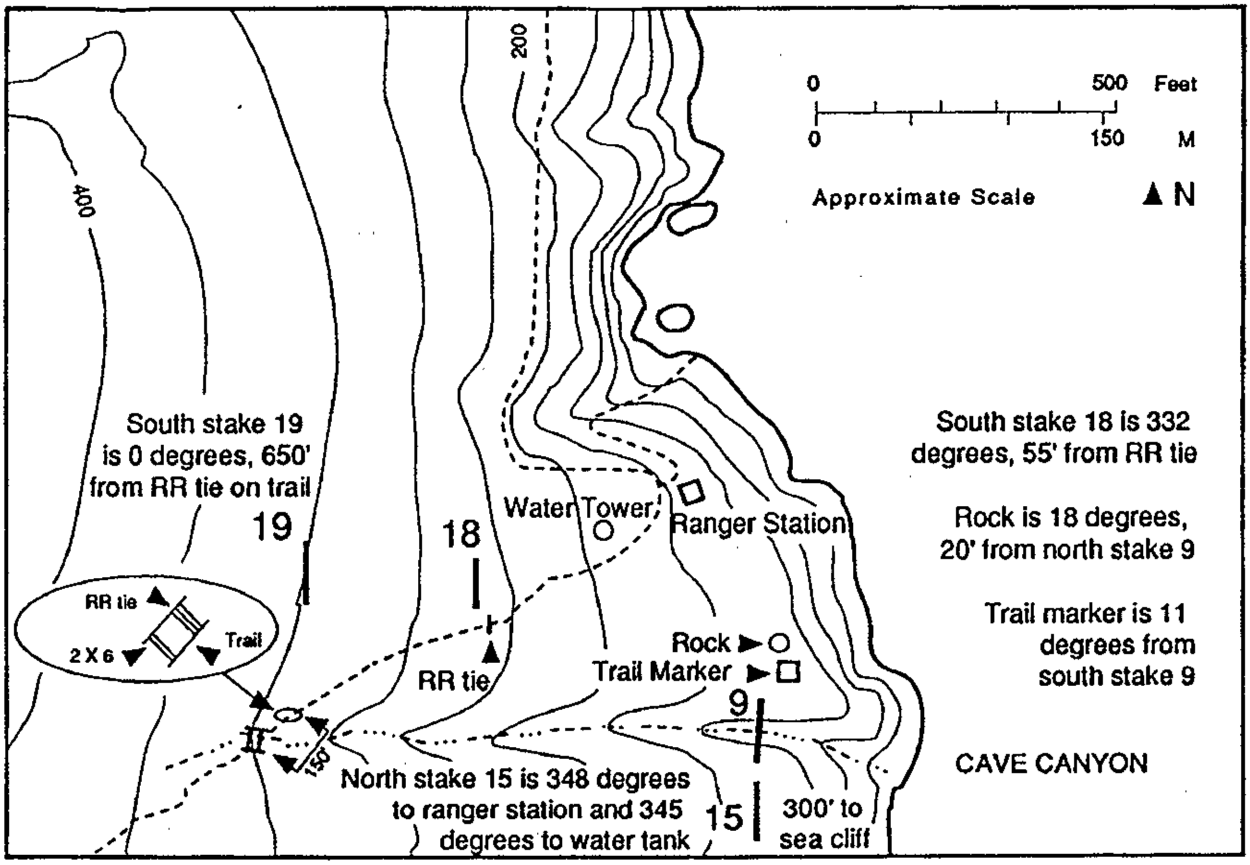


Figure 3c. Location of invertebrate sampling sites on Santa Barbara Island.

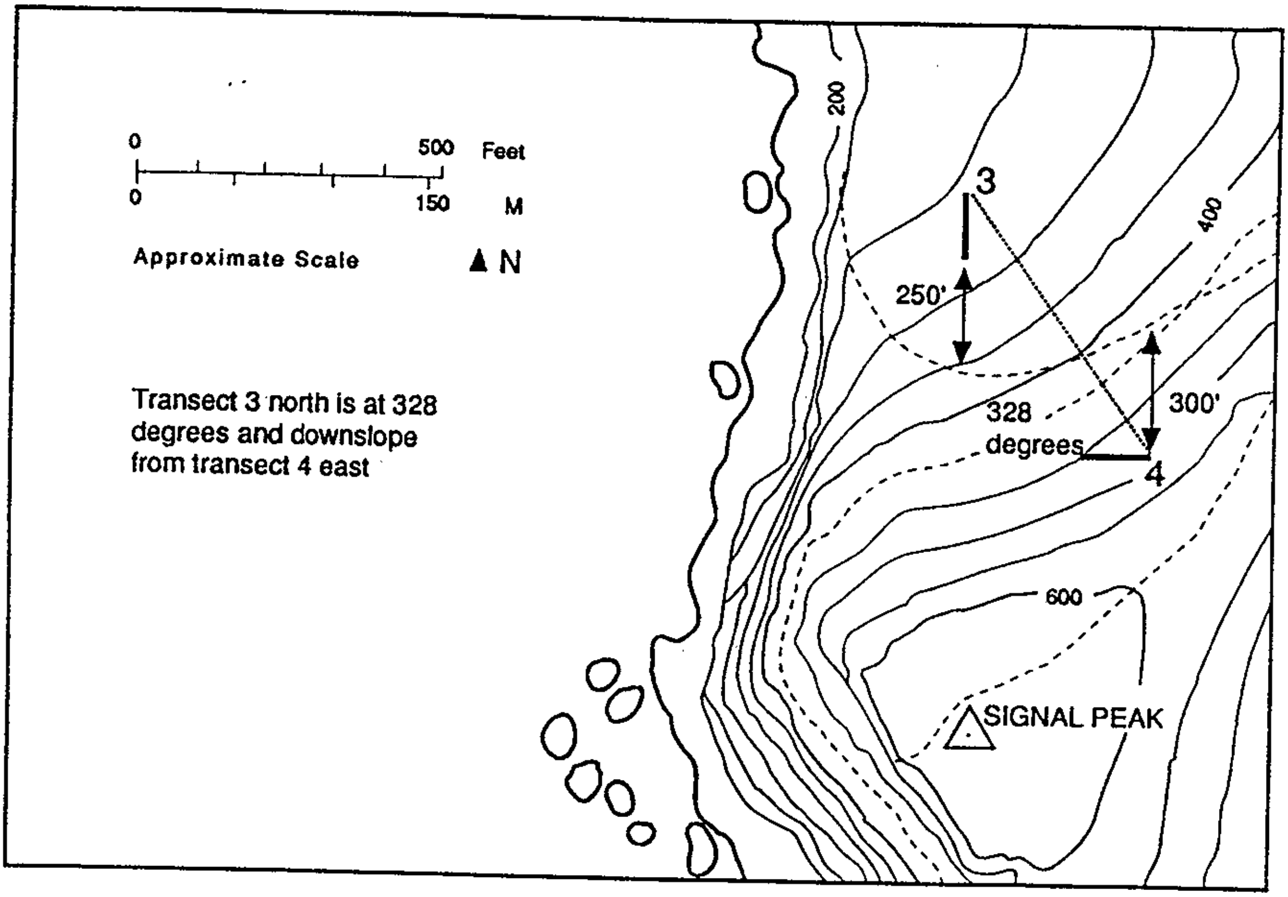


Figure 3d. Location of invertebrate sampling sites on Santa Barbara Island.

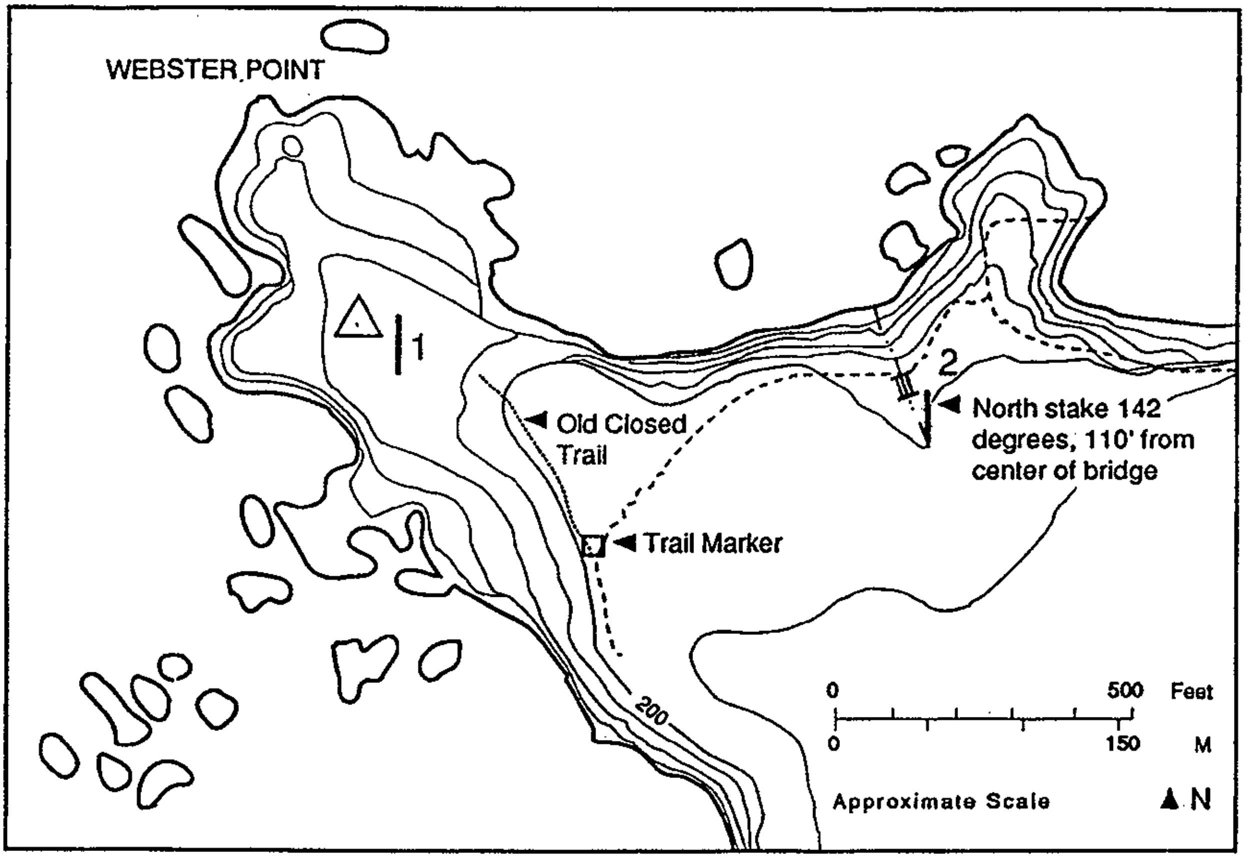


Figure 4a. Location of invertebrate sampling sites on San Miguel Island.

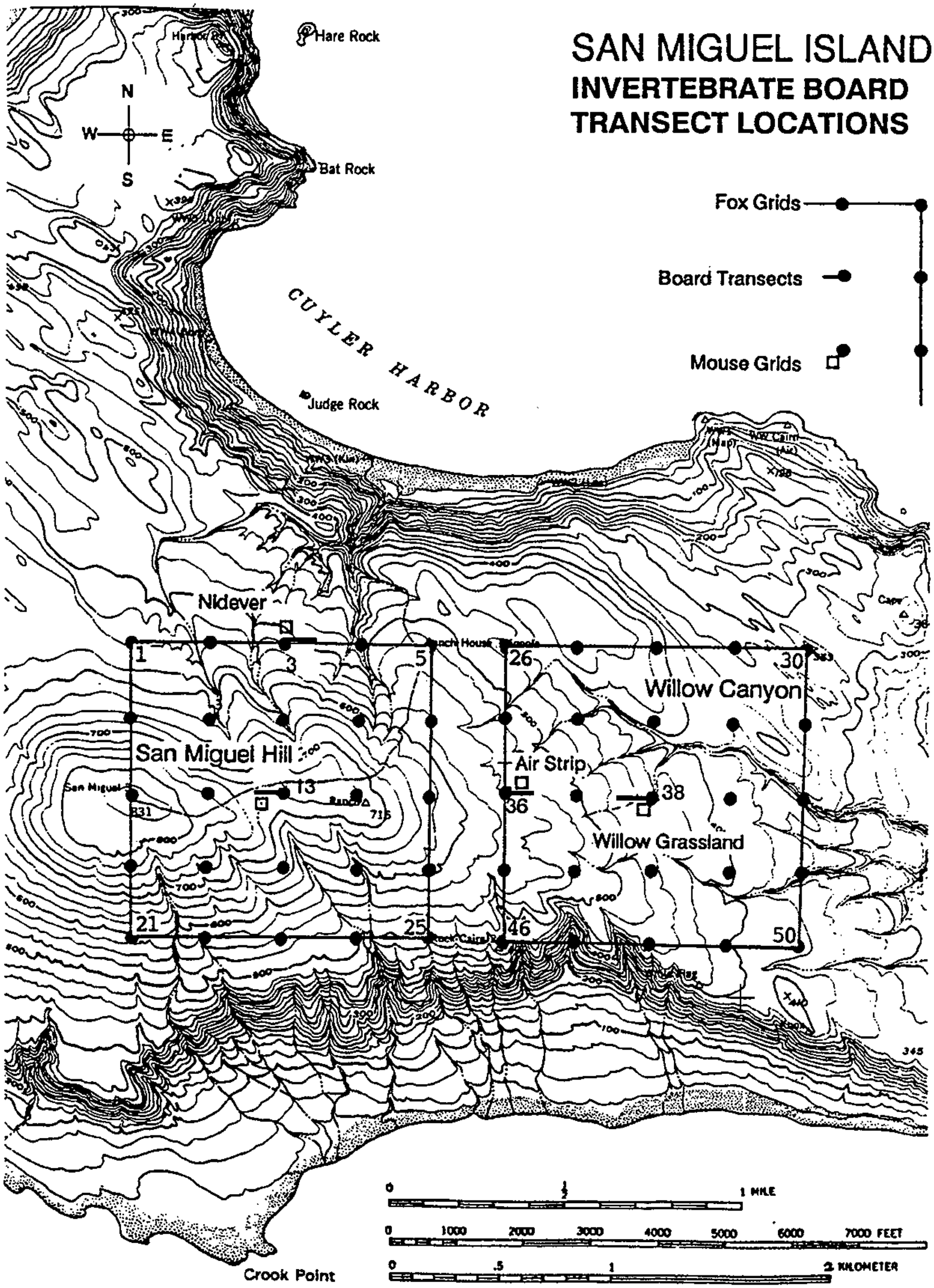
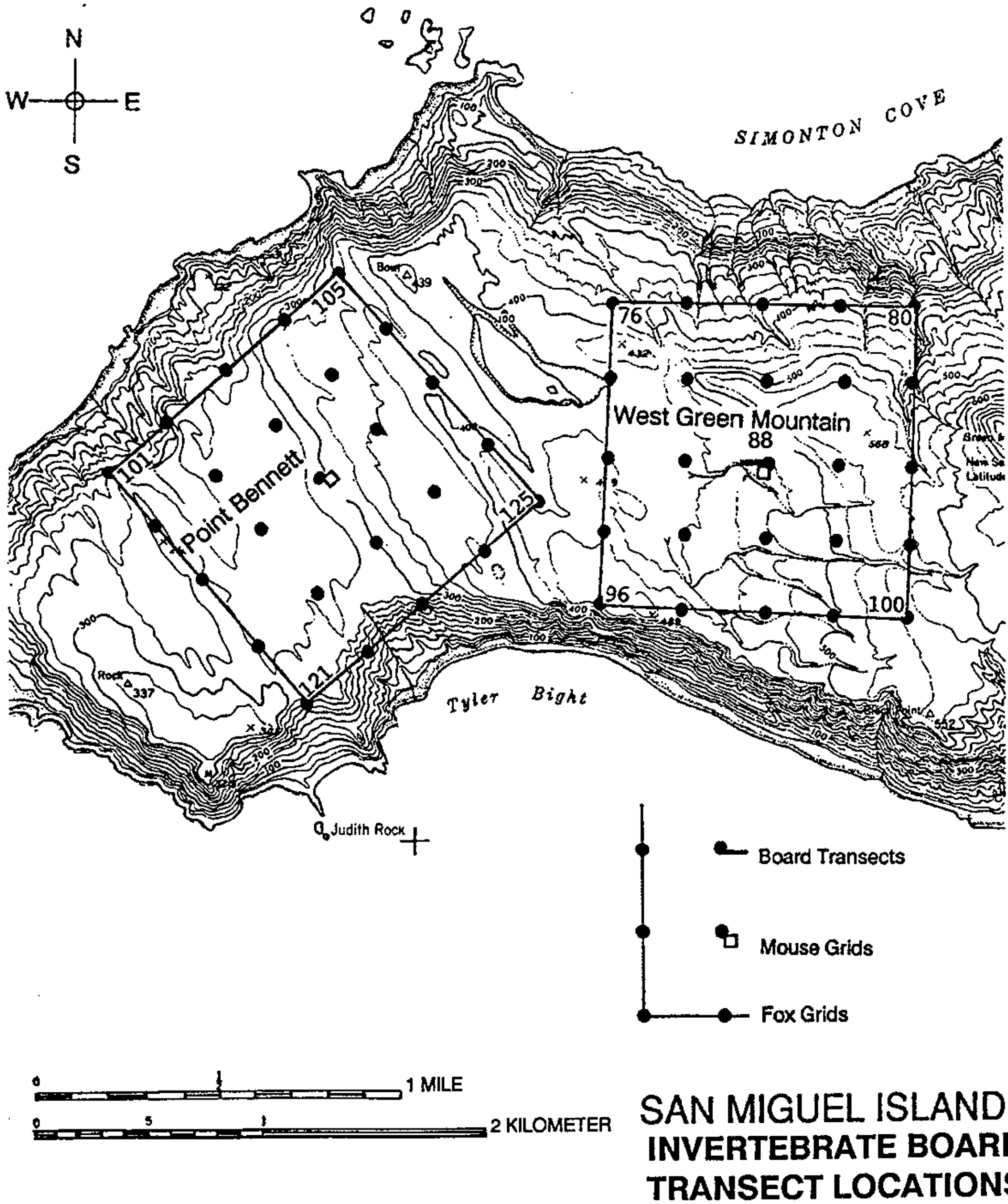


Figure 4b. Location of invertebrate sampling sites on San Miguel Island.



SAN MIGUEL ISLAND
INVERTEBRATE BOARD TRANSECT LOCATIONS

Figure 4c. Location of invertebrate sampling sites on San Miguel Island.

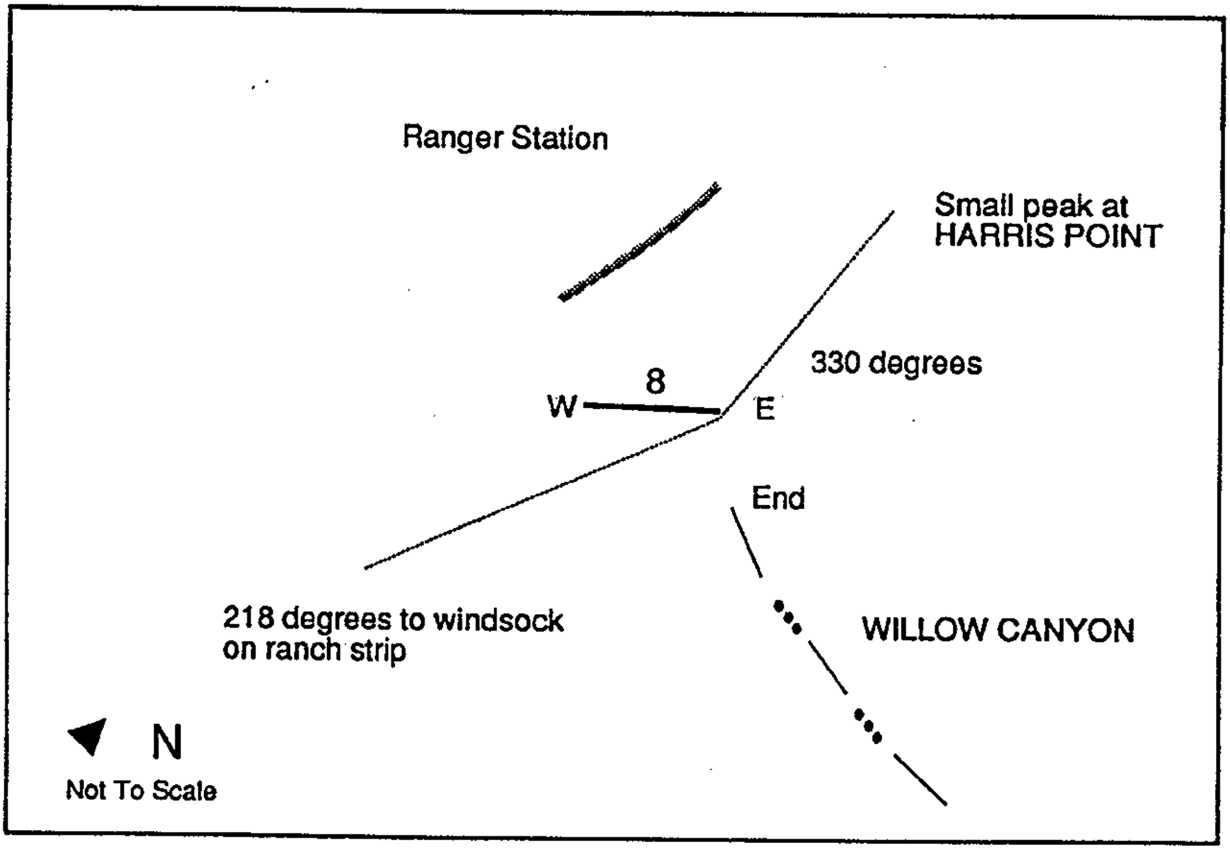


Figure 4d. Location of invertebrate sampling sites on San Miguel Island.

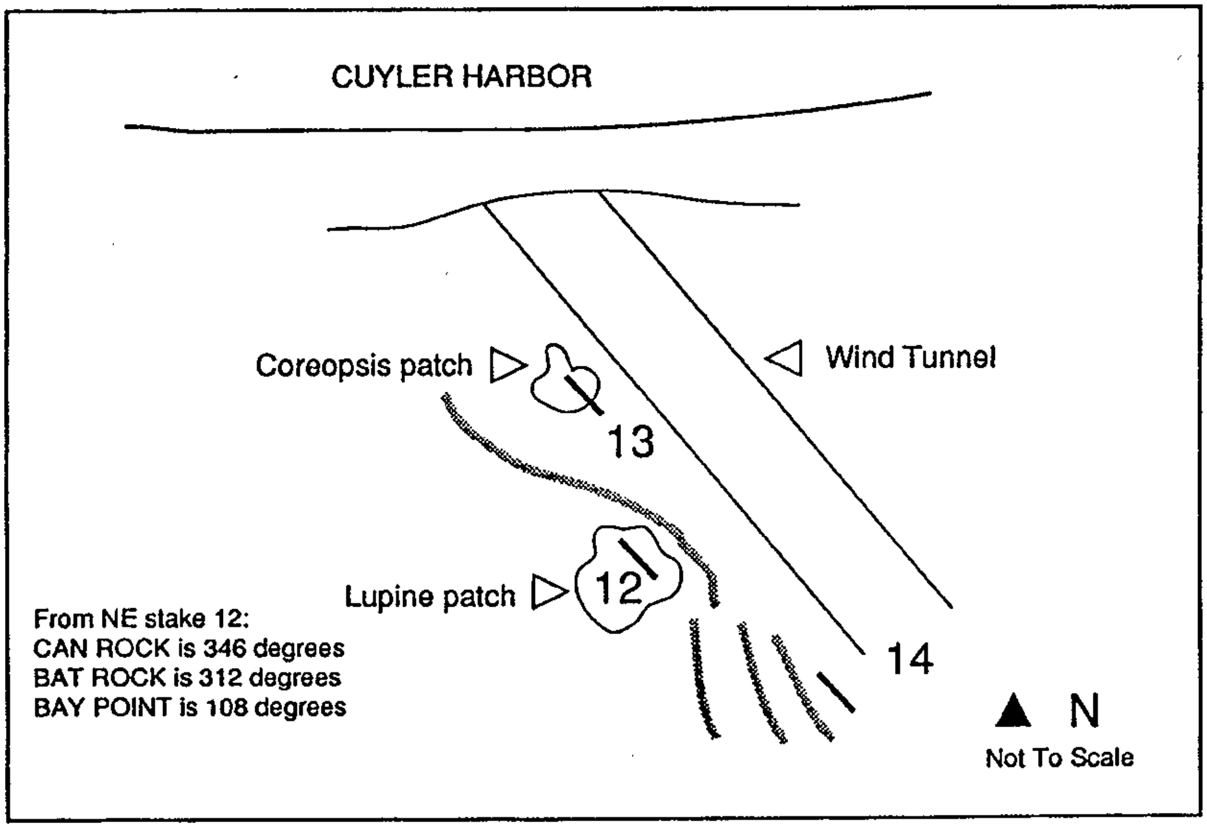


Figure 4e. Location of invertebrate sampling sites on San Miguel Island.

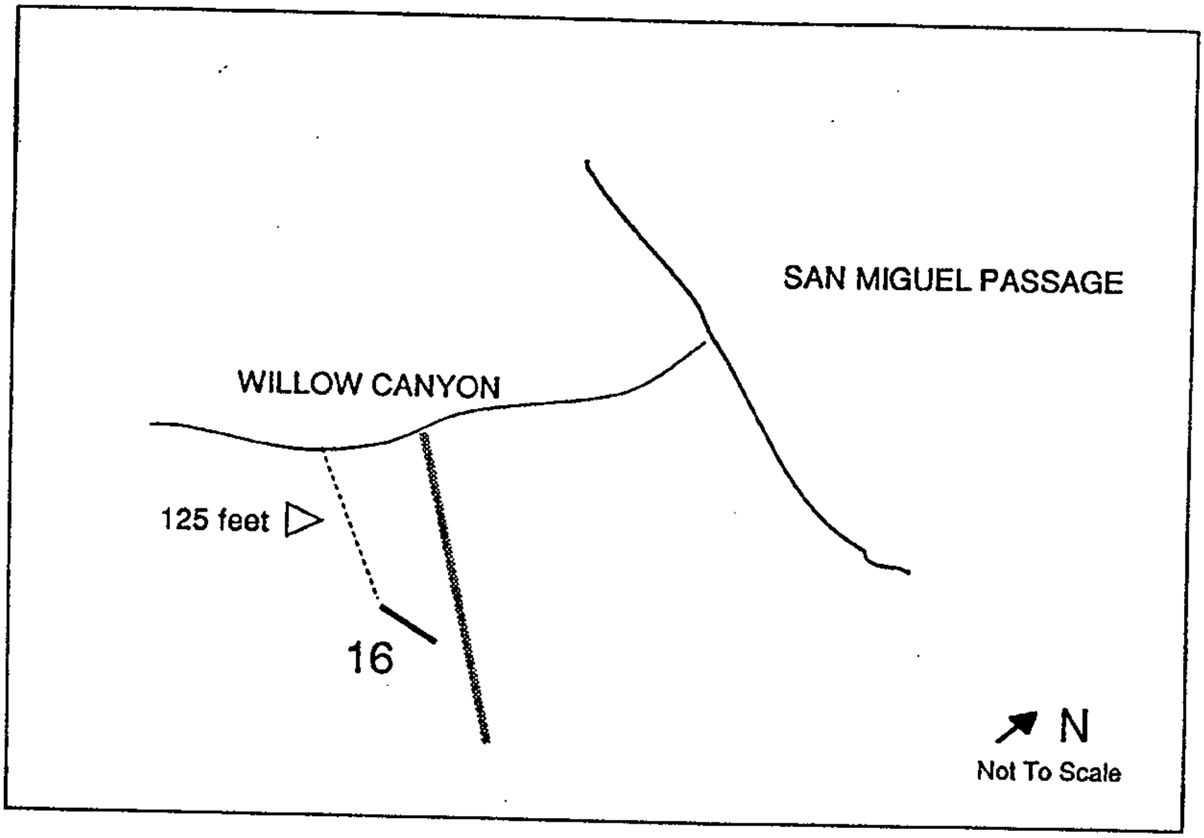


Figure 4f. Location of invertebrate sampling sites on San Miguel Island.

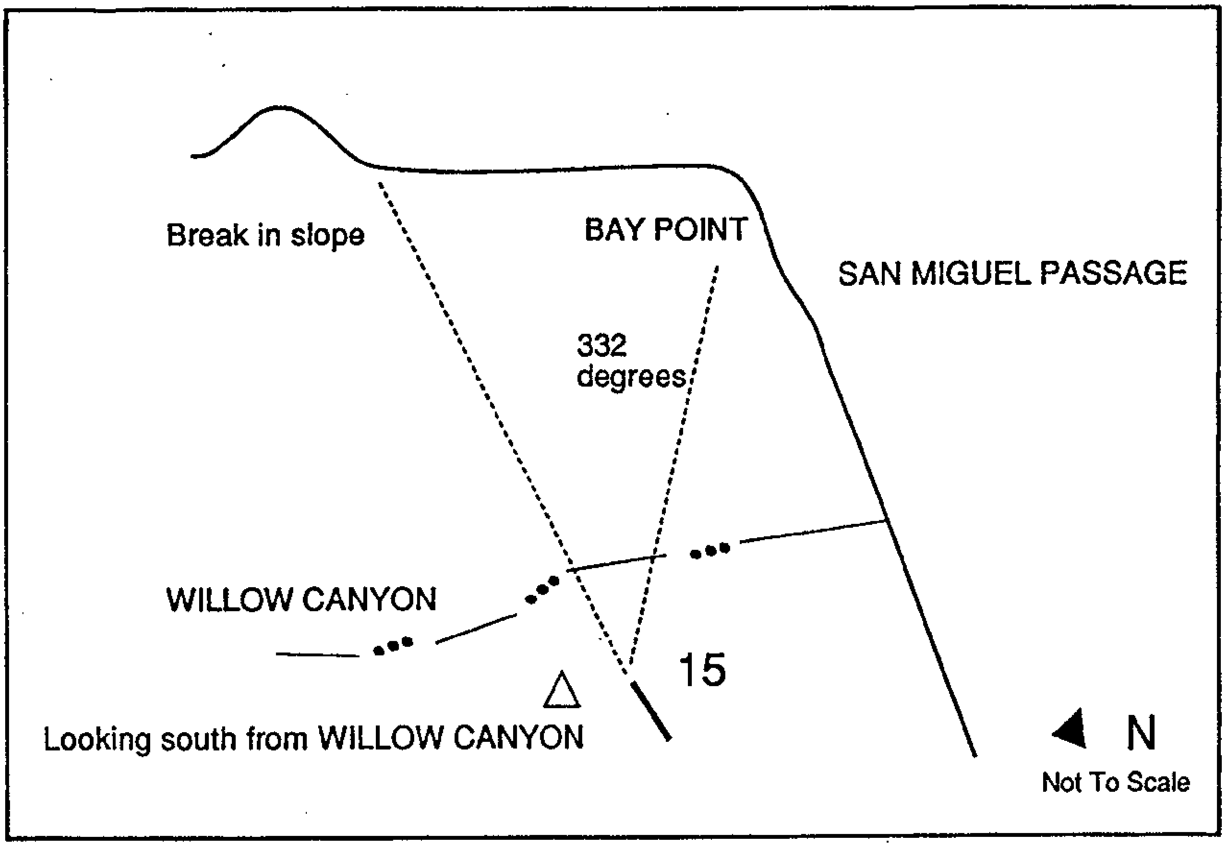


Figure 4g. Location of invertebrate sampling sites on San Miguel Island.

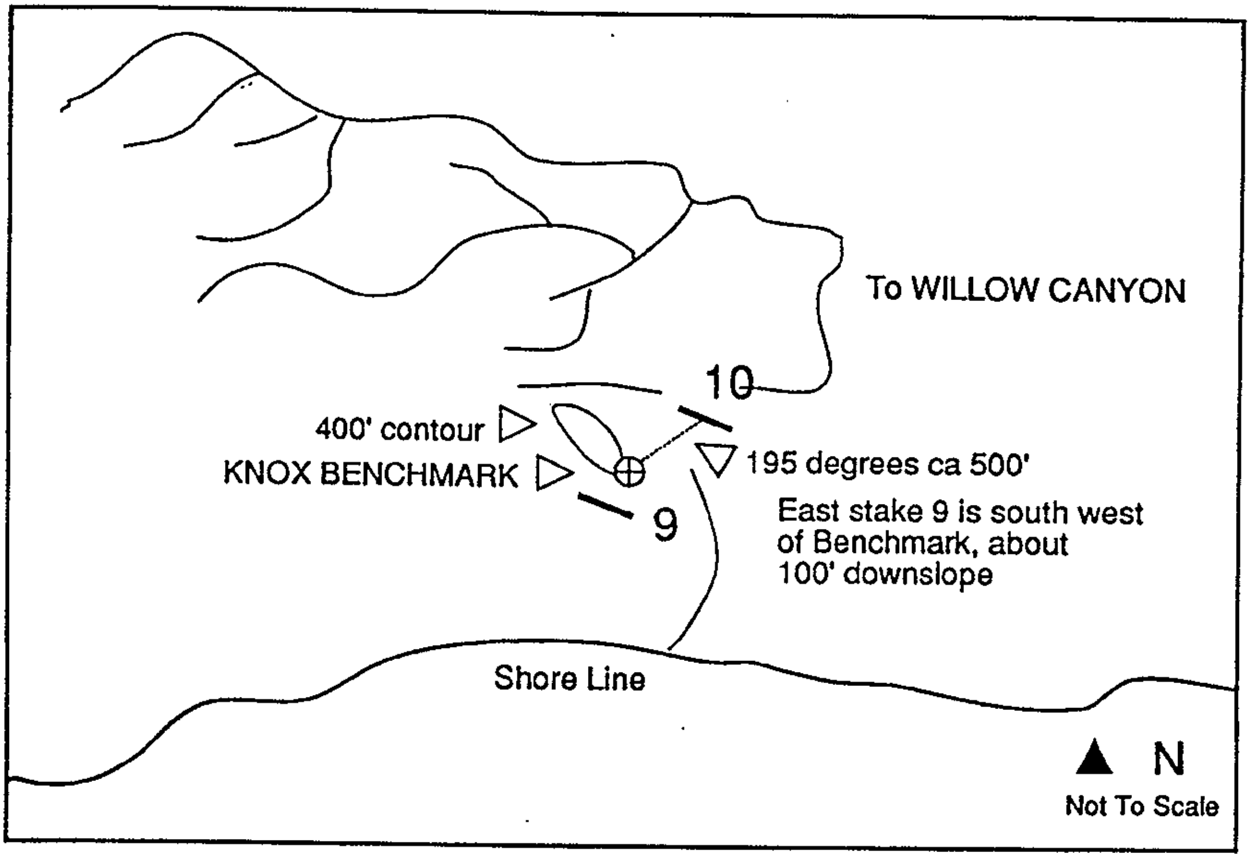


Figure 4h. Location of invertebrate sampling sites on San Miguel Island.

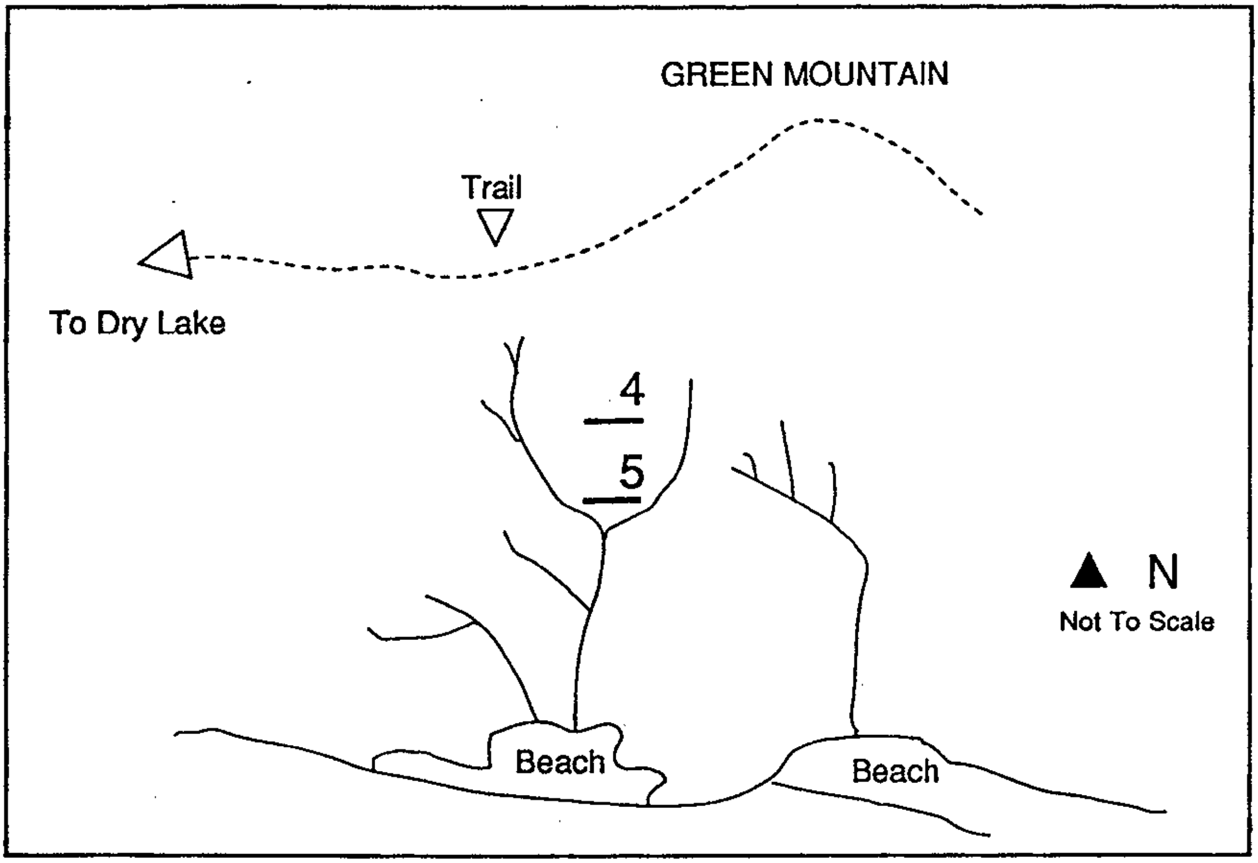
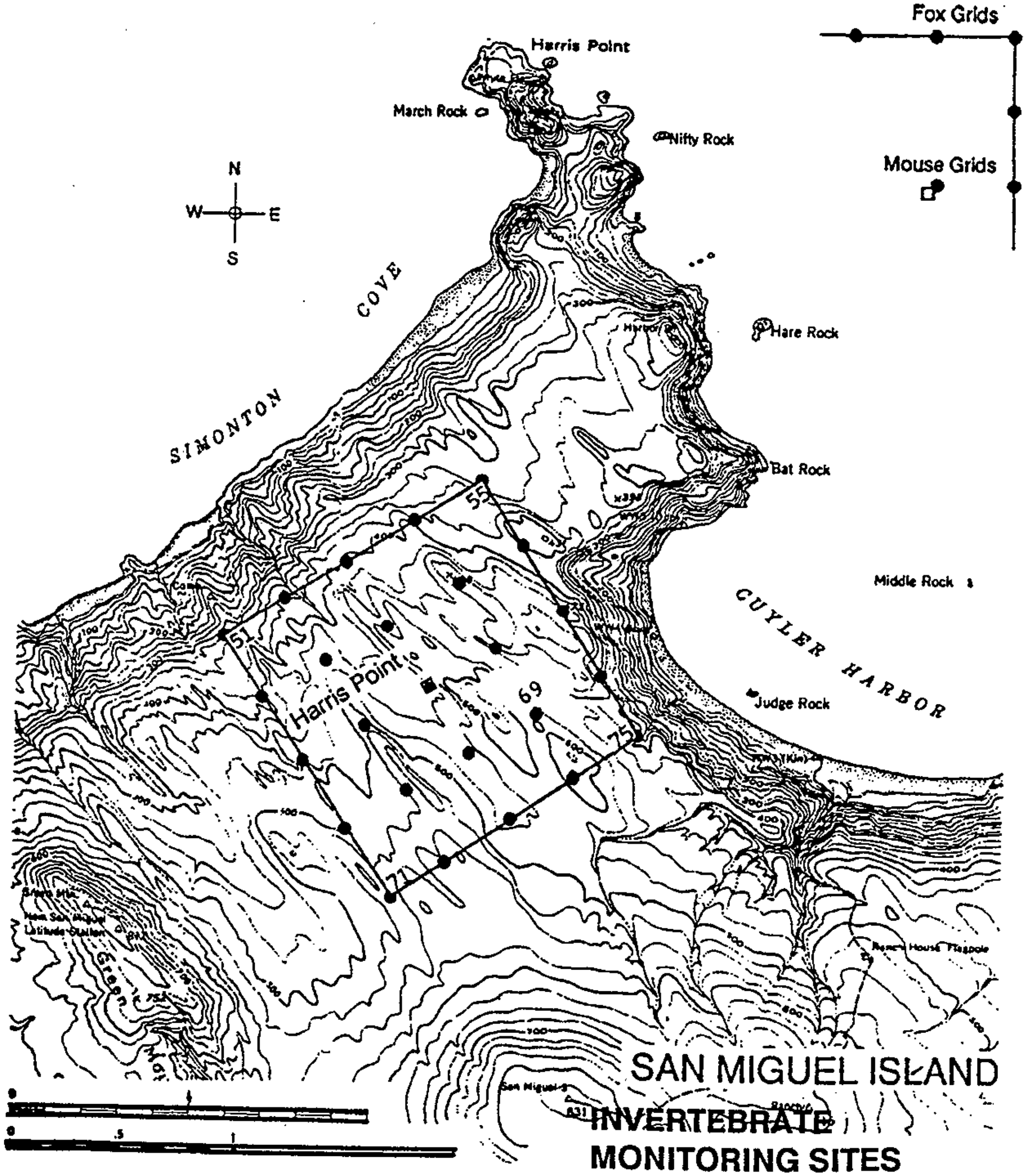


Figure 4i. Location of invertebrate sampling sites on San Miguel Island.



Appendix 7. Data entry form for cover boards.

Date ____________ Island ________ Observer ____________________________________

Site ________________ Technique ______________

Starting Time _________ Stopping Time __________

Weather ____

Appendix 8. Sample data for cover boards.

Date ____________ Island ______ Observer ____________________________

Site ________________ Technique ____________

Starting Time __________ Stopping Time __________

Weather ____

	Porcellio	Pseudoscorpion	Zelotes	Metacyrba	Lycosa	Coniontis	Protolophus	Porcellionides	Lepismatid						
701	15		2					40	3						
702	5	4		4			2	1	6						
703		1						10	10						
704	2		1		1		1	16	15						
705	10			1				35	14						
706	1	2				1		8	3						
707			1					36	8						
708	3			2				90	16						
709		3			large 1			12	7						
710	4	4	1				Small 1	9	4						
711				1				18	2						
712	2			1				40	7						
713	14	1	2		1			34	13						
714				2				60	17						
715	6							24	4						
716		4	1				1	12	8						
717	8				1			40	9						

Appendix 9. Data entry form for light trapping, malaise trapping, sweep sampling and vacuum sampling.

Date ____________ Island ______ Observer ______________________________________

Site _________________ Technique _____________

Starting Time __________ Stopping Time __________

Weather ____

Species	Number	Comments

Appendix 10. Sample data for light trapping, malaise trapping, sweep sampling and vacuum sampling.

Date April 15, 86 Island SBI Observer G. Fellers + C. Drost

Site CACA Technique M

Starting Time 8:00 am Stopping Time 11:00 am

Weather Clear skies, 0-2 knot wind

Species	Number	Comments
Geometrid sp. (red + brown)	12	
Eupithecia sp1	5	
Peridroma saucia	4	
Autographa sp	1	Collected
Apantesis proxima	2	
Ichneumonid sp (large)	1	Collected
Microlepidoptera sp.	3	Collected all 3

Appendix 11. Data entry program for invertebrate data for Anacapa, Santa Barbara and San Miguel Islands.

INVERT.prg

This is a data entry program for invertebragte data for Anacapa, Santa Barbara and San Miguel Islands. It uses files invert.dbf, invert_1.dbf, invert_d.dbf and invert_1.ndx.

Program was written by:

Gary M. Fellers
Point Reyes National Seashore

(415) 663-8562.

Program last updated: September 30, 1989

```
clear
clear all
set bell off
set deleted on
set carry off
set talk off
do while .T
    clear
    @  2, 25 to 4, 52 double
    @  6,  5 to 6, 75 double
    @  3, 30 say 'Invertebrate Data'
    @ 10, 25 say 'C     Enter count data'
    @ 12, 25 say 'S     Enter snail size data'
    @ 14, 25 say 'U     Update master species list'
    @ 16, 25 say 'D     Calculate species diversity'
    @ 18, 25 say 'Q     Quit'
    store 'Z' to choice
    set confirm off
    do while .not. choice $ 'CSUDQ'
      store ' ' to choice
```

```
    @ 21, 25 get choice picture '!'
    read
  enddo
  set confirm on
  clear
  do case
  case choice = 'C'
    select 1
    use invert
    select 2
    use invert_l
    if file ('invert_l.ndx')
       set index to invert_l
    else
       @ 10, 26 say 'Indexing Invert_l.dbf file.'
       index on upper(genus)+upper(species) to invert_l
       clear
    endif
    select 1
    if .not. bof()
       go bottom
       store date          to mdate
       store island        to misland
       store observer      to mobserver
       store locality      to mlocality
       store weather       to mweather
       store genus         to mgenus
       store species       to mspecies
       store str(number,4)   to mnumber
    else
       store date()        to mdate
       store space(2)      to misland
       store space(15) to mobserver
       store space(6)      to mlocality
       store space(20) to mweather
       store space(20) to mgenus, mspecies
       store space(4)      to mnumber
    endif
    store space(1)        to mtech
    store space(4)  to mstart, mstop
    store space(45) to mcomment
    store 'Z' to choice
    do while choice  'X'
       @  0,  0 say 'Last date   '
       @  1,  0 say 'Last species'
       @  2,  0 say 'Last number '
```

```
    @  2, 22 to 4, 55 double
    @  6,  5 to 6, 75 double
    @  3, 27 say 'Invertebrate Data Entry'
    @  8,  4 say ;
'Date          (mm/dd/yy)       Island     (EA, ;
MA, WA, SB, SM)'
    @ 10,  4 say 'Weather  '
    @ 12,  4 say ;
'Locality                    Observer'
    @ 14,  4 say ;
'Technique   (B, L, M, S, V)          Start;
        Stop'
    @ 16,  4 say ;
'Genus                        Species'
    @ 18,  4 say 'Number           Comment'
    do while choice  'X'
     @ 0, 14 say mdate
     @ 1, 14 say substr(trim(genus) + ' ' + ;
     trim(species)  + space(40),1,50)
     @ 2, 14 say number
     @ 19, 0 clear
     if choice'E'
      store space(20) to mgenus, mspecies
      store space(4)  to mnumber
      store space(40) to mcomment
     endif
     clear gets
     set confirm on
     if choice' '
      @ 23, 15 say 'Press PgDn to jump to menu'
      @  8, 15 get mdate
      @  8, 53 get misland    picture '@!'
      @ 10, 15 get mweather
      @ 12, 15 get mlocality  picture '@!'
      @ 12, 53 get mobserver
      @ 14, 15 get mtech      picture '!'
      @ 14, 53 get mstart     picture '9999'
      @ 14, 71 get mstop      picture '9999'
     endif
     @ 16, 15 get mgenus
     @ 16, 53 get mspecies
     @ 18, 15 get mnumber     picture '9999'
     @ 18, 33 get mcomment
     read
     @ 19, 0 clear
     store upper(mgenus) + upper(mspecies) to mgs
     store upper(substr(mgenus,1,1))  + ;
```

```
    lower(substr(mgenus,2,25)) to mgenus
    store lower(mspecies) to mspecies
    select 2
    seek mgs
    if found()
      store class to mclass
      store order  to morder
      store family to mfamily
      store native to mnative
      store phylo  to mphylo
      store 'Y' to found
    else
      store 'N' to found
    endif
    select 1
    if found='N' .or. val(mnumber)=0 .or. ;
       (val(mstop)al(mstart).and. mtech'L').or. ;
       .not. mtech  $ 'BLMSV' .or. (misland'EA' .and. ;
       misland'MA'.and. misland'WA' .and. misland'SB';
       .and. misland'SM') .or. mdate('01/01/85')
     set bell on
     ? chr(7)
     set bell off
     do case
       case found='N' .or. mgenus='    '
         @ 20, 15 say ;
'The genus and species were not found on the master list.'
       case val(mnumber)=0
         @ 20, 15 say '     The number is zero or blank.'
       case (val(mstop)al(mstart))
         @ 20, 15 say ;
'The stop time was earlier than the start time.'
       case .not. mtech $ 'BLMSV'
         @ 20, 15 say ;
'The technique you selected is not appropriate.'
       case misland'EA' .and. misland'MA'.and. ;
       misland'WA' .and. misland'SB' .and. ;
       misland'SM'
         @ 20, 15 say 'The choice of island is not ;
          appropriate.'
       case mdate        ('01/01/85')
         @ 20, 15 say 'The date you entered is not;
         appropriate.'
     endcase
     @ 21, 5 say ;
'This record will not be added to the data base unless it ;
```

```
is edited.'
          @ 22,  0 say "
          wait ;
'                  Press any key to continue . . . '
          @ 19, 0 clear
          @ 21, 15 say 'Press E  to edit entry.'
          @ 22, 15 say ;
'      D  to delete this record and continue.'
          @ 23, 15 say ;
'      X  to delete this record and exit program.'
          store 'Z' to choice
          set confirm off
          do while .not. choice  $ 'EDX'
            store ' ' to choice
            @ 24, 21 get choice picture '!'
            read
          enddo
          set confirm on
          @ 20, 0 clear
          loop
        endif
        @ 20, 15 say ;
'Press  RETURN to add more data for current locality ;
and technique.'
        @ 21, 15 say '       E to edit entry.'
        @ 22, 15 say ;
'       L to enter new locality or technique.'
        @ 23, 15 say '       X to exit and save current data.'
        store 'Z' to choice
        set confirm off
        do while .not. choice  $ ' ELX'
          store ' ' to choice
          @ 24, 22 get choice picture '!'
          read
        enddo
        if choice'E'
          append blank
          replace date with mdate, island with misland
          replace observer with mobserver
          replace locality with mlocality, weather with mweather
          replace technique with mtech, start with val(mstart)
          replace stop with val(mstop), genus with mgenus
          replace species with mspecies, comment with mcomment
          replace number with val(mnumber), class with mclass
          replace order with morder, family with mfamily
          replace phylo with mphylo, native with mnative
```

Appendix 11. Cont.

```
        endif
      enddo
    enddo
  case choice='S'
   select 1
   use snail
   select 2
   use invert_l
   if file('invert_l.ndx')
     set index to invert_l
   else
     @ 10, 26 say 'Indexing Invert_l.dbf file.'
     index on upper(genus)+upper(species) to invert_l
     clear
   endif
   select 1
   if .not. bof()
     go bottom
     store date      to mdate
     store island    to misland
     store observer  to mobserver
     store locality  to mlocality
     store genus     to mgenus
     store species   to mspecies
   else
     store date()    to mdate
     store space(2)  to misland
     store space(15) to mobserver
     store space(6)  to mlocality
     store space(20) to mweather
     store space(20) to mgenus, mspecies
     store space(4)  to mnumber
   endif
   store 0           to mlength
   store space(45)   to mcomment
   store 'Z' to choice
   do while choice  'X'
     @  0,  0 say 'Last date  '
     @  1,  0 say 'Last species'
     @  2,  0 say 'Last length '
     @  2, 26 to 4, 51 double
     @  6,  5 to 6, 75 double
     @  3, 31 say 'Snail Data Entry'
     @  8,  4 say ;
'Date             (mm/dd/yy)          ;
Island     (EA, MA, WA, SB, SM)'
```

Appendix 11. Cont.

```
    @ 10,  4 say ;
'Locality                          Observer'
    @ 12,  4 say ;
'Genus                              Species'
    @ 14,  4 say 'Length            Comment'
    do while choice  'X'
      @ 0, 14 say mdate
      @ 1, 14 say substr(trim(genus) + ' ' + trim(species) + ;
      space(40),1,50)
      @ 2, 14 say length
      @ 19, 0 clear
      if choice'E'
        store 0          to mlength
        store space(40) to mcomment
      endif
      clear gets
      set confirm on
      if choice' '
        @ 23, 15 say 'Press PgDn to jump to menu'
        @  8, 15 get mdate
        @  8, 53 get misland    picture '@!'
        @ 10, 15 get mlocality  picture '@!'
        @ 10, 53 get mobserver
      endif
      @ 12, 15 get mgenus
      @ 12, 53 get mspecies
      @ 14, 15 get mlength      picture '9999'
      @ 14, 33 get mcomment
      read
      @ 15, 0 clear
      store upper(mgenus) + upper(mspecies) to mgs
      store lower(mspecies) to mspecies
      store upper(substr(mgenus,1,1)) + ;
      lower(substr(mgenus,2,25)) to mgenus
      select 2
      seek mgs
      if found()
        store phylo  to mphylo
        store 'Y' to found
      else
        store 'N' to found
      endif
      select 1
      if found = 'N' .or. mgenus = '  ' .or. mspecies = '  '.or. ;
      mlength = 0 .or.(misland'EA' .and. misland'MA'.and. ;
      misland'WA' .and. misland'SB' .and. ;
```

```
       misland'SM').or. mdate('01/01/85')
        set bell on
        ? chr(7)
        set bell off
        do case
         case found='N' .or. mgenus='     '
          @ 20, 15 say ;
'The genus and species were not found on the master list.'
         case mgenus=' ' .or. mspecies=' '
          @ 20, 15 say ;
' The genus or species name was blank.'
         case mlength=0
          @ 20, 15 say '       The length is zero.'
         case mdate      ('01/01/85')
          @ 20, 15 say ;
'The date you entered is not appropriate.'
         case misland'EA' .and. misland'MA'.and. ;
         misland'WA' .and. misland'SB' .and. misland'SM'
          @ 20, 15 say ;
'The choice of island is not appropriate.'
        endcase
        @ 21, 5 say ;
'This record will not be added to the data base unless it is
edited.'
        @ 22, 0 say ''
        wait ;
'             Press any key to continue . . . '
        @ 19, 0 clear
        @ 21, 15 say 'Press E to edit entry.'
        @ 22, 15 say ;
'     D to delete this record and continue.'
        @ 23, 15 say ;
'     X to delete this record and exit program.'
        store 'Z' to choice
        set confirm off
        do while .not. choice $ 'EDX'
         store ' ' to choice
         @ 24, 21 get choice picture '!'
         read
        enddo
        set confirm on
        @ 20, 0 clear
        loop
       endif
       @ 20, 15 say ;
'Press RETURN to add more data for current locality.'
```

Appendix 11. Cont.

```
      @ 21, 15 say '      E to edit entry.'
      @ 22, 15 say ;
'     L to enter new locality or technique.'
      @ 23, 15 say '      X to exit and save current data.'
      store 'Z' to choice
      set confirm off
      do while .not. choice  $ ' ELX'
        store ' ' to choice
        @ 24, 22 get choice picture '!'
        read
      enddo
      if choice'E'
        append blank
        replace date with mdate, island with misland
        replace observer with mobserver
        replace locality with mlocality, genus with mgenus
        replace species with mspecies, length with mlength
        replace comment with mcomment, phylo with mphylo
        replace native with mnative
      endif
    enddo
  enddo
case choice='U'
  @  2, 22 to 4, 57 double
  @  6,  5 to 6, 75 double
  @  3, 27 say 'Invertebrate Species List'
  @ 10, 30 say 'A  Add species'
  @ 12, 30 say 'D  Delete species'
  @ 14, 30 say 'E  Edit species'
  @ 16, 30 say 'X  Exit'
  store 'Z' to choice
  set confirm off
  do while .not. choice  $ 'ADEX'
    store ' ' to choice
    @ 19, 30 get choice picture '!'
    read
  enddo
  set confirm on
  @ 10, 0 clear
  store space(20) to morder, mfamily, mgenus, mspecies
  store space(10) to mclass
  store space(5) to mphylo
  do case
  case choice='A'
    store ' ' to mnative
    @  8, 25 say 'Class'
```

Appendix 11. Cont.

```
    @ 10, 25 say 'Order'
    @ 12, 25 say 'Family'
    @ 14, 25 say 'Genus'
    @ 16, 25 say 'Species'
    @ 18, 25 say 'Native      (Enter N or E)'
    @ 20, 25 say 'Phylo'
    @  8, 33 get mclass
    @ 10, 33 get morder
    @ 12, 33 get mfamily
    @ 14, 33 get mgenus
    @ 16, 33 get mspecies
    @ 18, 33 get mnative  picture '!'
    @ 20, 33 get mphylo   picture '999.9'
    read
    use invert_l
    if file('invert_l.ndx')
      set index to invert_l
    else
      index on upper(genus)+upper(species) to invert_l
    endif
    append blank
    replace family with mfamily, genus with mgenus
    replace species with mspecies native with mnative
    replace phylo with val(mphylo)
  case choice='D'
    @ 10, 25 say 'Genus'
    @ 12, 25 say 'Species'
    @ 10, 33 get mgenus
    @ 12, 33 get mspecies
    read
    use invert_l
    if file('invert_l.ndx')
      set index to invert_l
    else
      index on upper(genus)+upper(species) to invert_l
    endif
    @ 8, 0 clear
    store upper(mgenus)+upper(mspecies) to mgs
    seek mgs
    if found()
      store ' ' to choice
      store 'Delete '+trim(mgenus)+' '+trim(mspecies)+ ;
      '?' to mgs
      @ 10, 22 say mgs
      @ 14, 28 say 'Enter Y or N'
      @ 16, 36 get choice
```

```
    set confirm off
    read
    set confirm on
    if upper(choice) = 'Y'
      delete
    endif
  else
    @ 10, 25 say 'Species not found. '
    @ 12,  0 say ' '
    wait ;
'                    Press any key to continue. '
  endif
case choice = 'E'
  @ 10, 25 say 'Genus'
  @ 12, 25 say 'Species'
  @ 10, 33 get mgenus
  @ 12, 33 get mspecies
  use invert_l
  if file('invert_l.ndx')
    set index to invert_l
  else
    index on upper(genus) + upper(species) to invert_l
  endif
  @ 8, 0 clear
  store upper(genus) + upper(species) to mgs
  seek mgs
  if .not. found()
    @ 10, 25 say 'Species not found. '
    @ 20,  0 say ' '
    wait ;
'                    Press any key to continue. '
  else
    store class to mclass, order to morder, ;
    family to mfamily, phylo to mphylo, native to mnative
  endif
  @ 10, 25 say 'Class'
  @ 12, 25 say 'Family'
  @ 14, 25 say 'Genus'
  @ 16, 25 say 'Species'
  @ 18, 25 say 'Native       (Enter N or E)'
  @ 10, 33 get mclass
  @ 12, 33 get mfamily
  @ 14, 33 get mgenus
  @ 16, 33 get mspecies
  @ 18, 33 get mnative   picture '!'
  read
```

```
        replace class with mclass, order with morder
        replace family with mfamily, genus with mgenus
        replace species with mspecies native with mnative
      endcase
    case choice = 'D'
      @ 2, 23 to 4,·55 double
      @ 6,  5 to 6, 75 double
      @ 3, 28 say 'Invertebrate Diversity'
      use invert
      store '  ' to misland
      store '    ' to myear
      store ' ' to mtech
      store ' ' to mnative
      store 'Z' to choice
      @ 10, 15 say 'Island         (EA, MA, WA, SB, SM)'
      @ 12, 15 say 'Year'
      @ 14, 15 say ;
  'Technique       (Board, Light, Malaise, Sweep, Vacuum)'
      @ 16, 15 say ;
  'Native         (N = Native, E = Exotic, A = All)'
      do while choice'X'
        @ 10, 26 get misland  picture '@!'
        @ 12, 26 get myear
        @ 14, 26 get mtech    picture '@!'
        @ 16, 26 get mnative  picture '@!'
        read
        if (misland  'EA' .and. misland  'MA' .and. ;
        misland  'WA' .and. misland  'SB' .and. ;
        misland  'SM') .or. val(myear)°0 .or. ;
        val(myear)2050 .or..not. mtech $ 'BMLSV' .or. ;
        .not. mnative $ 'NEA'
          set bell on
          ? chr(7)
          set bell off
          do case
            case misland  'EA' .and. misland  'MA' .and. ;
            misland  'WA' .and. misland  'SB' .and. ;
            misland  'SM'
              @ 20, 15 say 'The island abbreviation was incorrect.'
            case val(myear)  1980 .or. val(myear)  2050
              @ 20, 15 say ;
'The year did not fall in the range of 1990 to 2050.'
            case .not. mtech $ 'BMLSV'
              @ 20, 15 say 'The technique must be B, M, L, S or V.'
            case .not. mnative $ 'NEA'
              @ 20, 15 say 'The native status must be N, E or A.'
```

```
    endcase
    @ 21, 15 say 'A diversity index can not be calculated.'
    @ 22,  0 say ''
    wait ;
'          Press any key to continue . . . '
    @ 18, 0 clear
    @ 20, 15 say 'Press E  to edit entry.'
    @ 21, 15 say ;
'   X  to delete this record and exit program.'
    store 'Z' to choice
    set confirm off
    do while .not. choice  $ 'EX'
      store ' ' to choice
      @ 23, 21 get choice picture '!'
      read
    enddo
    set confirm on
    @ 18, 0 clear
    loop
  endif
  set filter to island=misland .and. year(date)=val(myear) ;
  .and. technique=mtech .and. native=mnative
  @ 8, 0 clear
  @ 10, 15 say 'Calculating diversity index. '
  set safety off
  copy to temp
  select 2
  use invert_d
  zap
  select 1
  use temp
  index on species to temp
  set safety on
  store species to mspecies
  store 0 to mnumber
  do while .not. eof()
    if species=mspecies
      store mnumber+number to mnumber
    else
      select 2
      append blank
      replace species with mspecies, number with mnumber
      select 1
      store species to mspecies
      store number to mnumber
    endif
```

```
      skip
    enddo
    select 1
    go top
    store 0 to p
    do while .not..eof()
      store p+(number*log(number)) to p
      skip
    enddo
    sum number to N
    H=((N*log(N))-p)/N
    @ 8, 0 clear
    @ 10, 15 say 'Shannon-Wiener Index of Species Diversity'
    @ 12, 15 say '       H = '
    @ 12, 28 say ltrim(str(H,6,2))
    @ 16,  0 say ''
    clear gets
    store 'X' to choice
    wait '            Press any key to continue. '
  enddo
 case choice='Q'
  close all
  erase temp.dbf
  erase temp.ndx
  use invert_d
  set safety off
  zap
  set safety on
  clear
  clear all
  set talk on
  cancel
 endcase
enddo
```

Appendix 12. Structure of dBase files.

Invert.dbf

Date	D	8
Island	C	2
Observer	C	25
Locality	C	6
Weather	C	30
Technique	C	1
Start	N	4
Stop	N	4
Genus	C	20
Species	C	20
Number	N	6
Comment	C	40
Native	C	1
Phylo	N	41
Class	C	10
Order	C	20
Family	C	20

Invert_l.dbf

Class	C	10
Order	C	20
Family	C	20
Genus	C	20
Species	C	20
AI	C	3
SBI	C	3
SMI	C	3
Comment	C	30
Native	C	1
Phylo	N	41

Invert_d.dbf

Species	C	25
Number	N	6

Snail.dbf

Date	D	8
Island	C	2
Observer	C	25
Locality	C	6
Genus	C	20
Species	C	20
Length	N	4

Comment	C	40
Phylo	N	41

Island		Brd	Lht	Mal	Swp	Vac
Anacapa Island						
Genus species	Site 1	-	-	-	-	-
	Site 2	-	-	-	-	-
	Site 3	-	-	-	-	-
Genus species	Site 1	-	-	-	-	-
	Site 2	-	-	-	-	-
	Site 3	-	-	-	-	-
Santa Barbara Island						
Genus species	Site 1	-	-	-	-	-
	Site 2	-	-	-	-	-
	Site 3	-	-	-	-	-
Genus species	Site 1	-	-	-	-	-
	Site 2	-	-	-	-	-
	Site 3	-	-	-	-	-
San Miguel Island						
Genus species	Site 1	-	-	-	-	-
	Site 2	-	-	-	-	-
	Site 3	-	-	-	-	-